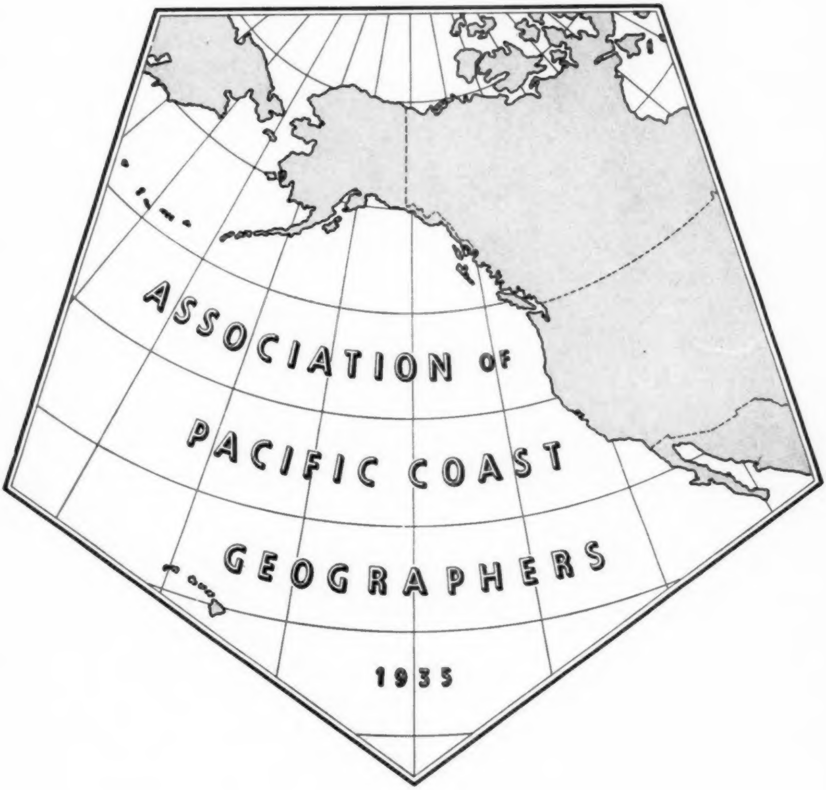

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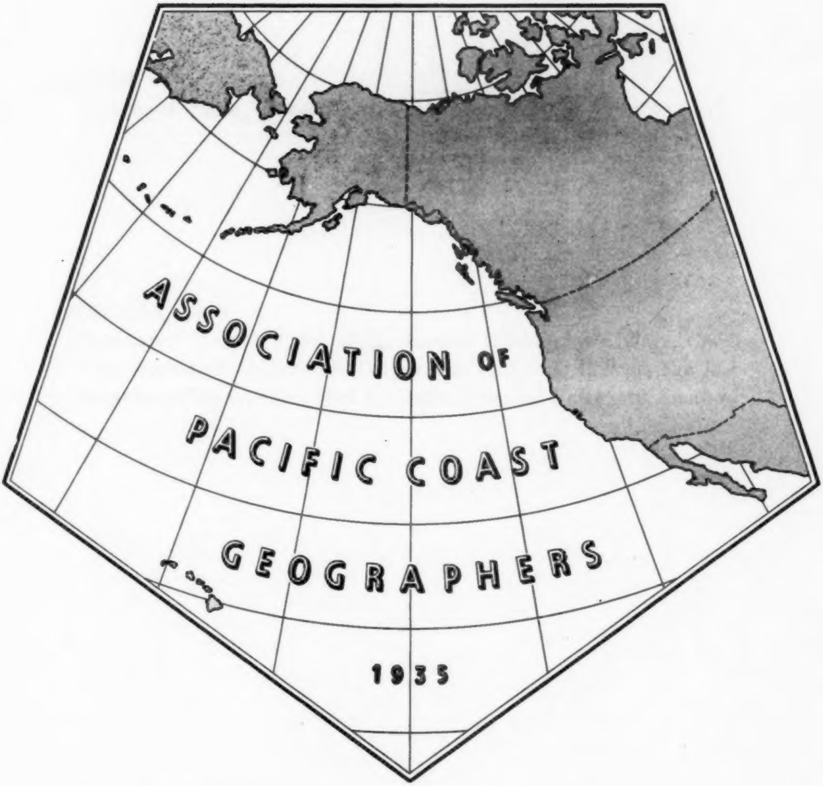

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CONTENTS

THE ROLE OF TRANSPORTATION IN THE FAIRBANKS AREA

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The Yukon River with its numerous affluents dominates the great central plain of Alaska. The valley of the Yukon provides ready access to a territory which stretches from the Brooks Range on the north to the Alaska mountain system on the south, and penetrates southeastward across the border in a great crescent deep into the Canadian Klondike. This master river, 2,300 miles in length, is also the central transport artery of the interior. Of its many affluents, none is more centrally located than the Tanana-Chena, where Fairbanks has become the recognized trade and transportation hub.

The city proper is located on the banks of the Chena River a few miles from its confluence with the Tanana, the urban area including a small portion of the southern fringe of the Yukon Tanana Upland with its gold bearing gravels. Here, placer mining was responsible for the founding and early growth of Fairbanks. A spur of the upland extends to the bank of the Tanana some eight miles west of Fairbanks; known as Chena Ridge, this spur marks the westernmost spread of settlement along the floodplain.

The right bank floodplain of the Tanana is relatively narrow because the stream has been deflected by the heavy deposition of tributary glacial streams from the Alaska Range to the south. Coriolis force, deflecting moving masses to the right in the northern hemisphere, also has contributed to this phenomenon.

Settlement is concentrated on the floodplain and the south facing slope of the adjacent upland. South of the river, the plain has never been settled. A military reservation, Ladd Air Force Base Bombing and Gunnery Range, is now located on the plain and, together with the difficulties and expense associated with bridging the river, will negate civilian settlement in this direction in the foreseeable future.

Surface transport arteries enter the area from the west and from the southeast. The Alaska Railroad reaches Fairbanks from the west after entering the valley via 2,363-foot Broad Pass through the Alaska Range. The Alaska Highway approaches from southeast via the low divide between the Tanana and White Rivers. This Canadian highway for passenger vehicles and trucks is joined at Big Delta, ninety miles southeast of Fairbanks, by the Richardson Highway, now a year-round link with tidewater at Valdez.

Viewed from the air in summer, the area surrounding Fairbanks is a mosaic of greens and blues. In the floodplain lowlands where the drainage is poor, the coloration varies from the light greens of mosses and lichens to the blue green of the black spruce. The small oxbow and ice-wedged lakes are ciel blue although shades deepen with the depth of the water. In the better-drained and undisturbed areas where spruce prevails and where burns have occurred, birch and aspen contribute their intermediate greens. In the

Fig. 1. Looking south across the Chena River toward the central business district of Fairbanks. At one time largely restricted to summer steamer service via the Yukon and Tanana rivers, Fairbanks is now the northern terminus of the Alaska Railroad and the Alaska Highway as well as an international air center for trans-Pacific and trans-Polar flights. Local air routes and highways fan out in every direction; the city is a supply point for numerous sub-Arctic and Arctic projects, military, scientific and commercial. *Wien Alaska Airlines photo by Frank Whaley.*

Yukon Tanana Uplands, stretching north of the city, a series of sharp crested ridges culminates in several higher peaks, commonly called domes. On the southern slopes of these ridges, which have been cut over and burned, birch and aspen make their appearance. On the northern slopes, moss and lichens are interspersed with the tell-tale black spruce—always an indicator that permafrost is near the surface. On south slopes, cleared fields planted to potatoes appear as light green or even white corduroy. On other areas, silage crops, occasional grain fields, and pastureland can be readily identified. In winter, however, the mosaic of blues and delicately varied greens is overlain with a vast and sweeping whiteness, in sharp contrast to the black-greens of the visible conifers. Both summer and winter landscapes invariably show the convergence of transport lines at Fairbanks. Indeed, the frozen ground of the winter season frees surface transport media from strict adherence to roads and railroad lines; heavy equipment and supplies are moved cross-country to outlying mining operations and defense installations by trucks, track-laying tractors, and four-wheel-drive vehicles.

Early Transportation in the Fairbanks Area

Until the beginning of the twentieth century, the Tanana Valley and the Fairbanks region were quite isolated and seldom visited by outsiders. One of the earliest recorded visits was made by a military expedition under the command of Lieutenant Henry T. Allen, United States Army, in the summer of 1885.[1] Lieutenant Allen made one of the first reliable maps of the Tanana Valley but, because of a shortage of food, the expedition moved rapidly and missed the mouth of Chena Slough. Succeeding expeditions made only cursory examinations of the area but in the summer of 1898 Alfred H. Brooks, the patriarch of Alaskan geologists, descended the Tanana with a United States Geological Survey party which prepared a detailed map of the Valley. Later the same year, a military expedition also went down the Tanana.[2] At the mouth of Chena Slough they found the fishing camp of an old Indian chief, the first recorded occupance in the Fairbanks area.

Traveling in this area was extremely difficult in the period before white settlement. Trails were scarce and of limited usefulness during the warm months because of widespread boggy conditions; pack horses were, therefore, of scant value in bringing in supplies during the prospecting season. The Tanana River and many of its tributaries were both difficult and dangerous for small boat travel because of rapids, swift currents, log jams, sweepers, and the cold, silt laden waters. Surface transportation routes which linked the Tanana Valley with the outside world were long and difficult. The sources of prospecting equipment and supplies were from three hundred to eight hundred miles round trip from the placer gravels of the Fairbanks area. It was not until the discovery of gold in the Klondike region of the Yukon Territory on August 16, 1896, that prospecting began throughout the Yukon River drainage basin.

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[1] Henry T. Allen, *An Expedition to the Copper, Tanana, and Koyukuk Rivers in 1885*, 49th Congress, 2d. session, Ex. Document 125, Senate Document 2449, map in pocket.

[2] Lieutenant J. C. Castner, *Narratives of Explorations in Alaska*, Senate Subreport No. 1023, 56th Congress, 1st Session (Washington: Government Printing Office, 1900), p. 692.

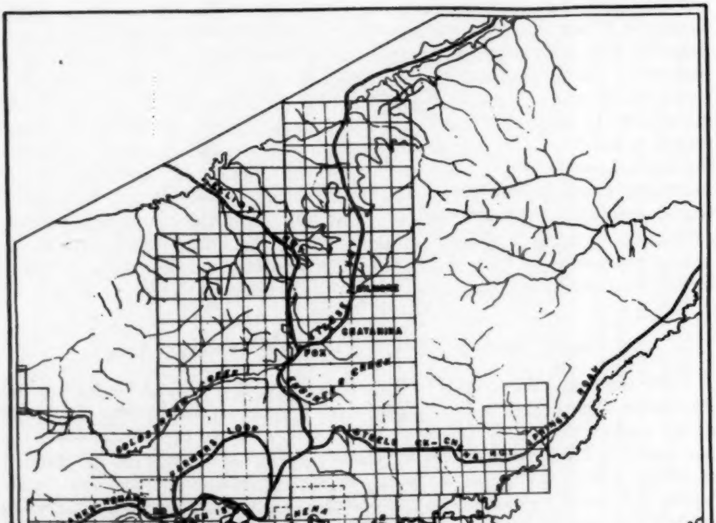
FAIRBANKS AREA
SCALE
MILES
LADD A.F.B. BOMBING AND GUNNERY RANGE
EIELSON A.F.B.
CHATANIKA
FOX
LADD A.F.B.

Fig. 2

The orginal gold strike near Fairbanks was aided in part by the difficulties of transportation in this region. In August of 1901, the "Lavelle Young" was trying to ascend the Tanana River to Tanana Crossing where the Valdez-Eagle Trail crossed the Tanana.[3] This vessel carried a load of trading goods owned by Captain E. E. Barnette, who planned to establish a trading post at Tanana Crossing. Either the swift current or the low water level of the river prevented the "Lavelle Young" from ascending Bates Rapids on the Tanana above the mouth of Chena Slough. Captain Adams, master of the vessel, had heard that the rapids could be bypassed by going up Chena Slough, and he dropped back to the mouth of the Chena to make the attempt, which proved impossible.

According to the terms of the contract, Adams was to land the goods at the point where upstream progress stopped. Captain Barnette persuaded him to drop back downstream several miles to a higher, well wooded area along the Chena where Barnette built a cache to store his trading goods for the winter; this marked the first known white settlement at the site. Felix Pedro and his partner, who were prospecting in the area, were delighted to find a source of supplies so close to their operations, Barnette's cache eliminating the three-hundred-mile round trip to Circle City. In July of the following year, 1902, Felix Pedro made his historic gold strike on Pedro Creek and Fairbanks became a mining camp.

River Boat Period, 1901 - 1923

Following the discovery of gold, the chief mode of transportation was the river boat. Two routes were used; one was from Skagway to Whitehorse in the Yukon Territory by the White Pass and Yukon Railway, thence on the Yukon and Tanana rivers to Fairbanks. The two customs clearances on this route were a disadvantage. The second ran from the Bering Sea port of St. Michael up the Yukon and Tanana rivers to Fairbanks and did not involve customs clearances.

The freight rates to Fairbanks were quite high in comparison with rates to Nome and other important Alaska mining camps. In 1904, the freight rates from Seattle to Fairbanks via St. Michael were from $135 to $220 per ton, depending upon the classification of the goods.[4] At the same time the rates from Seattle to Nome were from $15 to $35 per ton. The difference in freight charges between Fairbanks and Nome was due to the cost of river boat transport. Freight charges from Seattle to Nome and to St. Michael, the transfer point to river boats, were the same. This great differential on freight was due in part to the high costs of river boat operation and short open season as well as navigation hazards and fluctuations of the river level. However, some writers attributed the high cost of transportation to Fairbanks to the river transport monopoly held by the North American Transportation Company and the Northern Commercial Company.[5]

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[3] James Wickersham, *Old Yukon* (Washington: Washington Law Book Co., 1938), p. 185.

[4] C. W. Purrington, *Methods and Cost of Gravel and Placer Mining in Alaska*, U.S. Geological Survey, U.S. Department of the Interior, Bulletin 263 (Washington: Government Printing Office, 1905), p. 230.

[5] H. Erdmann, *Alaska: Ein Beitrag zur Geschichte der Nord-Kolonisation* (Berlin: D. Reimer, 1909), p. 112.

With regard to river transportation, Fairbanks had a relative disadvantage in comparison with the rival town of Chena, located at the confluence of the Chena and Tanana rivers. During low water stages on the Chena, Fairbanks was inaccessible for all except the small, shallow draft boats. It was then necessary to land Fairbanks goods at Chena for transshipment by smaller boats or by horse to Fairbanks—a serious competitive handicap.

Until the Alaska Railroad was built in the early 1920's, river boats carried most of the freight and supplies consigned to the Fairbanks area. Water transportation was seasonal and usually functioned from around the first of June to early October. River boat seasonality necessitated careful planning of successful business or mining operations and also considerable capital which was tied up in supplies over the winter. Supplies and machinery for early spring mining had to be on hand the preceding fall because the mining season opened before the river navigation season by as much as one month; furthermore, transport from river ports to the creeks was cheaper in winter because of the easier haulage over frozen ground.

Trails, Roads and an Early Railroad

Several other types of transportation were used in the early days of Fairbanks, including the dog team and sled in winter when the ground was frozen and snow-covered. These sleds were highly practical for Arctic work since the dogs could easily pull their light-weight but nutritious food in addition to their freight load. Dogs hitched in a single straight line to a narrow sled required little trail improvement; they traveled lightly over the winter snow cover and seldom broke through the crust. Chief form of winter transportation in the early days of the camp, dog sleds carried the mail to outlying areas for a number of years.

Pack horses were in great demand to move supplies from Fairbanks and Chena to the nearby gold producing creeks. Later subscriptions by the businessmen of Fairbanks financed the construction of wagon roads to replace pack trails.[6] As roads spanned the few short miles from Fairbanks to the auriferous creeks, freight rates from Fairbanks to the diggings declined two hundred to four hundred dollars per ton. By June, 1904, there was a bridge across the main channel of the Chena River which replaced the cable ferry from Fairbanks to Garden Island; the bridge had to be rebuilt annually until the construction of a steel bridge thirteen years later by the Alaska Road Commission.[7] Fairbanks prospered at the expense of the rival Chena, because of the cheaper and easier movement of men and materials over the wagon roads from Fairbanks to the creeks. The main road from Fairbanks to the mines extended along the west side of Birch Hill, up the valley of Isabella Creek, over the divide into Engineer Creek, down this valley for a short distance, and then up the Goldstream Valley to the vicinity of the present town of Fox, where the road branched to serve various creeks. (See Figure 2.) This road was shorter and crossed less swampy ground than the trails from Chena. The progressive attitude of its merchants helped Fairbanks overcome the water transportation disadvantage and outstrip Chena. By 1904, Fairbanks was the most important supply center in interior

[6] Purrington, *op. cit.*, p. 220.

[7] U.S. Army, *Report of the Board of Road Commissioners for Alaska 1917*, War Department (Washington: Government Printing Office, 1917), p. 15.

Alaska, eclipsing Circle, Eagle, Fort Yukon, Tanana, and other interior towns.[8]

In 1904, when Fairbanks was less than two years old, work was started on a railroad, promoted by Falcon Joslin, a Fairbanks attorney, and incorporated for $500,000 supplied by English investors. Equipment for the railroad was shipped on the last boats of the 1904 river season. The early river boat transportation was subject to various hazards, and the numerous rehandlings of the freight added further to the expense. The rails were transshipped eleven times between Seattle and Chena. Six flat cars, destined for the railroad and shipped during the same season, still rest in the bed of the Yukon River.[9]

The Tanana Valley Railroad was well engineered and adapted to permafrost, low marshy ground, and other northern railroad problems. Administrative and maintenance headquarters were originally built at Chena and later moved to Garden Island, across the slough from Fairbanks, following the decline and abandonment of the town of Chena. The road was dedicated and the last spike in the twenty-six mile line to Gilmore in the upper Goldstream Valley was driven on July 17, 1905. It was later extended to Chatanika in the Chatanika Valley at the mouth of Cleary Creek and operated over forty-five miles of track. This railroad was the first type of transportation in the Tanana Valley which was not seriously affected or stopped completely by the spring break-up or the fall freeze-up; it needed no seasonal conversion from runners to wheels.

The Fairbanks-Valdez Trail which later became the Richardson Highway was a major step in improving and diversifying transportation to Fairbanks. This route had its beginning in 1901, when Congress appropriated $100,000 for roads and trails in Alaska, most of the money being spent on the construction of a crude pack trail from Valdez to Fort Egbert at Eagle. In 1904, an additional fund was made available for the survey of a wagon road over the same route but this was not built because it was already evident that Fairbanks was a more important center than Eagle and Fort Egbert; therefore attention was turned toward providing a trail and road into this area. Official reports of the Alaska Road Commission state that the route was suitable for dog team travel by 1909.[10] Other government records show that this route was used at an earlier date and, in the winter of 1905-1906, Fairbanks was a mail distribution center for the interior and even for such distant points as Nome.[11] Enterprising Alaskans were operating a twice-weekly stage service over the route in the winter of 1906-1907. A new cutoff built in 1906 saved approximately fifty miles.

For a number of years, the Valdez-Fairbanks Trail was not usable in

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[8] L. M. Prindle, *The Gold Placers of the Fortymile, Birch Creek and Fairbanks Regions, Alaska,* Geological Survey, U.S. Department of the Interior, Bulletin No. 251 (Washington: Government Printing Office, 1905), p. 69.

[9] A. H. Brooks, *Report on the Progress of Investigations of Mineral Resources of Alaska in 1905,* Geological Survey, U.S. Department of the Interior, Bulletin No. 284 (Washington: Government Printing Office, 1906), p. 112.

[10] Alaska Road Commission, "Report Upon the Construction and Maintenance of Roads, Bridges, and Trails, Alaska," *Annual Report of the Chief Engineers to the Secretary of War 1924, Part II* (Juneau, Alaska: Alaska Daily Empire Print, 1924), p. 46.

[11] U.S. Congress, House, *Mail and Pack Trails in Alaska,* House Report No. 3875, 59th Congress, 1st. Session (Washington: GPO, 1906), p. 23.

summer where it crossed low, level ground which became a quagmire after the spring thaw, but after the freeze-up and the first snows the trail had a firm smooth surface and required only tree removal and some notching of hillsides to provide a suitable roadbed. The period of winter travel usually extended from early October through April.

The Fairbanks-Valdez Stage Company, incorporated in 1905 to provide winter travel, used sleds and horses to move freight and passengers. The rates quoted in 1907 were $150 per passenger from Valdez to Fairbanks, and $125 on the south-bound trip. Small quantities of freight were carried between these points for 75 cents a pound and large quantities for 50 cents a pound, or $1000 per ton.[12] During the winter of 1906-1907, some twenty-five hundred persons and about two thousand tons of freight moved over the route.[13] The equated cost of the winter transportation over the Fairbanks-Valdez Trail was $1,312,500, using the lower rates for freight and passengers. The amount expended for overland winter transportation was greater than 14 per cent of the total gold production in 1906.[14] Better facilities and reduction of costs were essential in increasing the availability of capital for permanent improvements and it was toward this goal that the residents directed their attention.

In 1910, the Alaska Road Commission rated the Fairbanks-Valdez Trail as the most important overland route in Alaska and it was improved as rapidly as funds would permit. By 1911, the trail was passable for light drawn wagons and, in the summer of 1913, the first truck and automobile passages were accomplished. This opened a new era of transportation for the Fairbanks area as cars were both faster and cheaper than horses. Although there were no roads classed as automobile roads until some years after World War I, regular mail and passenger service was maintained by motor vehicle for a number of years prior to this change in classification.

As mentioned earlier, the first wagon roads to the creeks were financed by contributions of the Fairbanks merchants and in 1915, despite a gradual decline in the output of gold, the Fairbanks Commercial Club contributed $5000 to the Alaska Road Commission for the construction of a sled trail to Chena Hot Springs. The highway system suffered during World War I. Funds for the Alaska Road Commission were drastically reduced and maintenance was inadequate. A shortage of labor, particularly the skilled type, was widespread in the Territory and hampered maintenance operations on the Richardson Highway, where there were a number of serious problems including bridge and road washouts caused by flooding glacial streams, glaciering, and heavy snows in the Thompson Pass area. Wages and the cost of supplies increased during the war period and provided another deterrent to road maintenance.

A bad washout, caused by a flood in Keystone Canyon some fifteen miles from Valdez, closed the southern end of the Richardson Highway in July,

[12] H. J. Brand, *Directory of the Tanana Valley, 1907* (Fairbanks, Alaska: Tanana Directory Co., 1907), p. 21.

[13] U.S. Army, *Report of the Board of Road Commissioners for Alaska to the Secretary of War, 1907,* War Department (Washington: Government Printing Office, 1907), p. 10.

[14] Philip S. Smith, *Past Placer-Gold Production from Alaska 1870-1930,* Geological Survey, U.S. Department of the Interior, Bulletin 857-B (Washington: Government Printing Office, 1934), p. 96. Fairbanks Gold Production in 1906—$9,000,000.

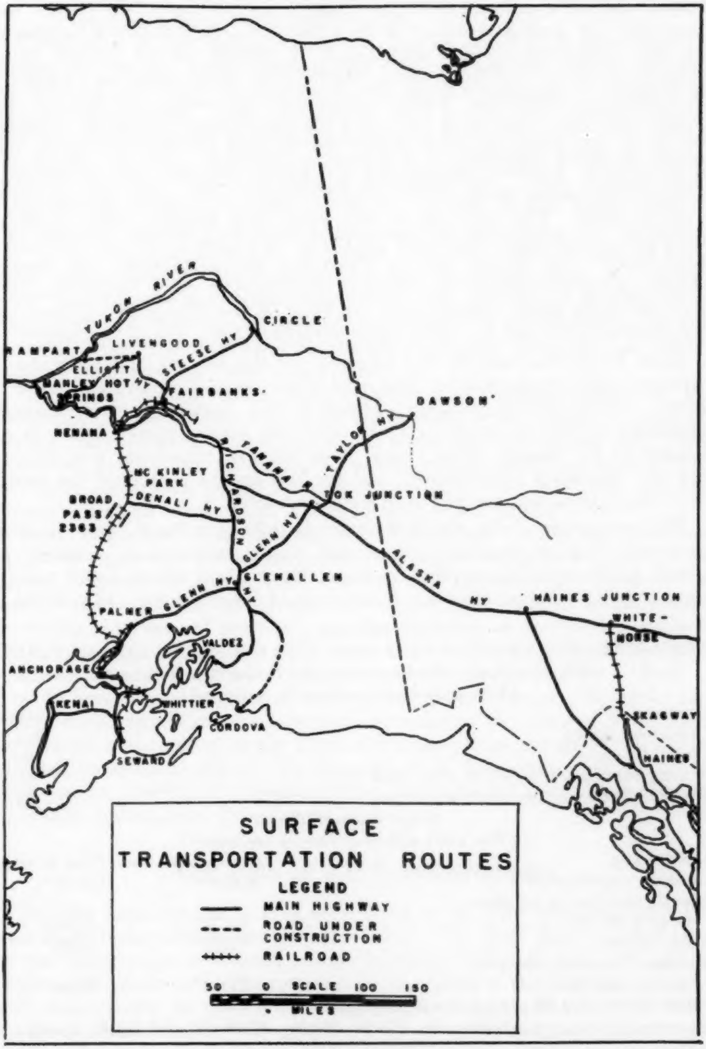

Fig. 3

1919, and for nearly two years overland movement to Fairbanks was via the Copper River and Northern Railroad, which was built in 1911 to Chitina where a branch road connected with the Richardson Highway.

The Alaska Railroad — Anchorage to Fairbanks

About the time World War I started in Europe, work was resumed on the

construction of a railroad from the coast to the interior. This project had long been the goal of residents of the Fairbanks area and had a number of capable champions in men like Alfred H. Brooks of the United States Geological Survey and Judge James Wickersham who represented Alaska as its delegate to Congress. Several routes were proposed, and the one currently used from Seward to Fairbanks via Broad Pass was finally selected. Work on the Fairbanks end of the line started in 1915 but proceeded rather slowly. Roadbed construction was finally completed on November 3, 1919, when narrow gauge track linked Fairbanks with North Nenana at the Tanana River. The government first leased the Tanana Valley Railroad during the government fiscal year 1916-1917 and later purchased it for some $300,000.[15] The branch line to Chatanika was maintained and regular service provided, but the branch to Chena was torn up in 1919 because it was not being used. Merchandise landings on the Chena docks were last recorded in 1917 and for all practical purposes Chena was abandoned.[16]

Even before the railroad was extended all the way to North Nenana, it was very useful to Fairbanks. The right of way crossed some good stands of spruce which were a valuable addition to the depleted and increasingly expensive supply of wood for fuel. After the narrow gauge line was extended to the Tanana River across from Nenana, some coal was shipped but the significant movement of coal for fuel had to wait until the bridge over the Tanana was completed in February, 1923.

The completion of the Alaska Railroad in 1923 gave Fairbanks reasonable assurance that dependable year-around transportation was available by which goods could be supplied more quickly at about one-half the price of river freight.[17] Actual rates are shown in the following table. (Table One.)

Table One
FREIGHT RATES, SEATTLE OR TACOMA TO SELECTED ALASKA POINTS
1923 Joint Rates, Water and Alaska Railroad to Fairbanks
(Ton units unless otherwise indicated)

Commodity	*Carload*
Groceries, mixed	$41.00
Flour, in sacks	28.20
Mining machinery, no piece over 4000 lbs.	30.00
Lumber, common, per 1000 board feet	21.10

Water Rates to Nome
(Ton units unless otherwise indicated)

Commodity	*Carload*	*Less Than Carload*
General merchandise	$16.00*	$19.00*
Mining machinery, no piece over 4000 lbs.	13.50*	16.00*
Coal, sacked	13.65*	15.65*
Lumber, common, not over 30 feet per M.	21.00*	23.00*

*Add $8.00 - $12.00 per ton for lighterage.

Source: NORMAN L. WIMMLER, *Placer Mining Methods and Costs*, Bureau of

[15] A. W. Greely, *Handbook of Alaska, Its Resources, Products and Attractions in 1924,* 3rd Edition (New York: Charles Scribners and Sons, 1925), p. 46.

[16] U.S. Department of the Interior, "Indian Affairs—Territories," *Annual Report of the Department of the Interior 1918,* Vol. II (Washington: Government Printing Office, 1919), p. 95.

[17] U.S. Army, *Annual Report of the Engineers to the Secretary of War 1926,* Part II (Juneau, Alaska: 1926), p. 30.

Mines, U.S. Dept. of the Interior, Bulletin No. 259 (Washington: Government Printing Office, 1927), p. 19.

Completion of the bridge across the Tanana River at Nenana and the change to standard gauge track on the Fairbanks section cleared the way for efficient movement of equipment and supplies adequate for large scale mining development. Following World War I, the gold mining industry had felt the increasing cost of supplies and declining fuel rather acutely but the railroad helped to lower the cost of fuel by providing direct connection with the extensive lignite deposits of the Healy area. Soon thereafter, the Fairbanks Exploration Company, later part of The United States Smelting Refining and Mining Company, began consolidating claims and moving in machinery in preparation for a big scale, long term development of lower value placer ground. Preparations included the construction of a powerhouse fired by coal to provide electricity for the operation of its dredges. A cheap source of fuel was of primary importance for dredge operation and for many years the Fairbanks Exploration Company has been one of the chief customers of the Healy coal fields.

Caterpillar tractors, which came into the transportation picture in the latter part of the 1920's, were used for moving heavy freight to outlying mining camps during March and April, when the ground was still frozen and snow covered but the period of lowest temperatures had passed. Several large sleds were pulled by each caterpillar. The usual daily run was twenty miles and, about 1930, tractors rented at $40 to $50 a day.[18]

After completion of the rail line, the Alaska Road Commission embarked upon a program of road improvement designed to create new traffic for the Alaska Railroad. The local road network was expanded and improved to provide better service for farmers and mining operators. A major project extending over several years was the development of the Fairbanks-Circle Trail, first put through as a sled road, then reconstructed to wagon road standards and later improved and renamed the Steese Highway. Built to provide access to a number of mining properties between Fairbanks and Circle, it also gave Circle an overland route during the summer. This highway added new territory to the Fairbanks trading area and eased the supply problem for mining camps in the area. By 1936, the extension of the Elliott Highway to Livengood brought another mining area into the expanding Fairbanks trading area (See Figure 1).

The Role of Air Transportation

The first airplanes in the area were those of an Army experimental flight from New York to Nome and return in 1920. The Army flight was followed by the introduction of airmail service between Fairbanks and McGrath in 1924 by Ben Eielson.[19] After proving the feasibility of the airplane in Alaska and participating in several remarkable polar flights, he established the Farthest North Airplane Company in Fairbanks. Prospectors, miners, and trappers adopted plane travel with alacrity, covering distances in a few hours that formerly took days and weeks, and saving money as well. The

[18] James M. Hill, *Lode Deposits of the Fairbanks District, Alaska,* Geological Survey, U.S. Department of the Interior, Bulletin No. 849-B (Washington: Government Printing Office, 1933), p. 54.

[19] Merle Colby, *Alaska* (New York: Macmillan Co., 1939), p. 93.

airplane was widely used on mercy missions, flying the seriously ill and injured to centers like Fairbanks where medical and hospital facilities were available, thus reducing one of the great hazards of isolation—the possibility of being injured or becoming ill with no means of effective treatment. Many missions were flown under adverse conditions and at great personal risk to the pilots. This valuable service is still performed, chiefly through the Air Search and Rescue units of the United States Air Force.

Weeks Field was started in 1928 with the building of two 400-foot by 2,000-foot runways. Other fields were built in the surrounding territory at Brooks (on the Tolovana River), Fort Yukon, Palmer Creek (in the headwaters area of the Chena River), and Circle Hot Springs, service to outlying points being provided by planes based at Fairbanks.

Originally, Weeks Field was a transport asset to Fairbanks because it was located on the borders of the city and provided air travelers with quick and easy access to the business district. In fact, it was so close that it was troubled by winter fog over the city. With the help of the Civilian Conservation Corps, one runway was extended to Chena Slough which enabled planes to escape the fog and also facilitated the seasonal change from wheels to floats which was carried out on many aircraft. After the war, the rapid addition of larger two- and four-engine planes made Weeks Field totally inadequate. Expansion of the field was out of the question because there was already a serious safety problem caused by traffic pattern intersections with Ladd Air Force Base flights; the runways of Ladd Field were less than three miles from Weeks Field and led directly over it. This conflict was resolved by closing Weeks Field as an airport on October 15, 1951.[20] The former Weeks Field has now been transformed into one of the better planned residential and apartment areas of the city.

For several years, the Air Force permitted use of its facilities by commercial multi-engine ships on a limited basis, but this proved unsatisfactory for both the Air Force and the commercial operators. After considerable agitation, Congress finally approved funds for a new airport located outside the area of traffic interference with military operations. The new International Airport is some five miles west and south of Fairbanks. (See Figure 2.) With a 6,000-foot runway which was adequate for multi-engine operation, the field has been extended 4,000 feet to meet jet aircraft requirements. The surfaced runway, taxiway, control tower, and other physical assets represent an investment of nearly five and one-half million dollars and current additions will bring the total to ten million dollars.[21]

The local bush pilots and small private plane owners did not like the high fees levied at the new field or the restrictions set up for operations. Their reaction may be interpreted as a protest against the passing of frontier conditions in air transportation. The solution to their problem was the construction of privately owned and operated Phillips Field on Garden Island. Here the oiled runway is about four thousand feet long, and adequate for the small plane operation so prevalent in the sub-Arctic.

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[20] Richard A. Cooley, *Fairbanks, Alaska. A Survey of Progress,* Alaska Development Board (Juneau, Alaska: July 1954), p. 43.

[21] Alaskan Employment Security Commission, "Labor Market Newsletter, Fairbanks Area, December 1, 1958," p. 2.

The Alaska Highway

Soon after the completion of the Alaska Railroad in 1923, Fairbanks and other towns began working for a highway connection to the United States. In 1930, a commission studied the possibilities of such a highway and subsequent investigations were sponsored by both the United States and Canadian governments. The United States reported favorably on the project and was ready to proceed. However, much of the proposed road was located in Canada and during the 1930's that country had more pressing projects, but the Second World War and the ferry route for delivering planes to Russia made the Alaska road-link a strategic necessity. In the interests of national defense, the United States provided funds for construction of the highway. In less than nine months after the beginning of construction, in March, 1942, the road was pushed through from Dawson Creek, British Columbia, and an overland link between Fairbanks and the United States was established.[22]

The pioneer road was steadily improved and became an important communication line during the war. In addition to serving as a supply line for the airfields along the ferry route to Russia, it was also a service road for the Petroleum Products' pipeline from Whitehorse to Fairbanks and other intermediate points. Opened to limited civilian traffic in 1946 and with the improvement of the road and the service facilities, the Highway was soon opened to the general motoring public.

Rehabilitation of the Alaska Railroad

The Alaska Railroad was in poor condition at the outbreak of the Second World War; its rolling stock was old and decrepit, much of it dating back to the construction of the Panama Canal, the rails were light and badly aligned, the track poorly ballasted, and many wooden bridges were in need of repair or replacement. Under army operation, the road was improved and delivered substantial amounts of construction material, military supplies, and freight to Fairbanks. During the war the line was extended by the Army to serve Ladd and Eielson air fields, an extension which is still in use under the jurisdiction of the Alaska Railroad.

In 1947, Congress authorized funds for the general rehabilitation of the Alaska Railroad. The track was changed from 70-pound to 115-pound rail, treated ties were put down, and a new seven and one-half million dollar terminal built at Fairbanks.[23] This included seventy-five industrial sites with spur tracks on Garden Island, most of them leased shortly after completion of the project. Finished in 1950, this terminal has repair, maintenance, and service facilities for rolling stock, as well as additional storage track. New plants and warehouses have been built on the industrial sites, adding measurably to economic diversification in Fairbanks.

The Petroleum Products pipeline extending from Haines, Alaska, to Fairbanks was opened in 1954. This 615-mile line which parallels much of the Alaska Highway was built to serve the military installations in the Tanana

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[22] U.S. Army, *The Alaska Highway*, Public Relations Branch, Northwest Service Command, Mimeograph and Multilith Section, U.S. Signal Corps, 1944, p. 15.

[23] U.S. Department of the Interior, *Annual Report of the Alaska Railroad Fiscal Year, 1950*, Alaska Railroad (Washington: Government Printing Office, n.d.), p. 5.

Valley and along the Highway; the cost was in excess of thirty million dollars.[24] With the opening of this pipeline, revenue of the Alaska Railroad dropped immediately.

Conclusion

Today, Fairbanks is well served by numerous types of transportation, various private firms as well as the United States Government having invested large sums in new equipment and permanent installations. Regular freight service by truck is maintained between Fairbanks and Valdez, Anchorage, and Seattle, Washington. Scheduled air service connects Fairbanks with the major towns in Alaska, the United States, and Canada, while contract and charter flights carry goods and passengers to almost any point in Alaska. The Alaska Railroad still moves the bulk of the freight, picking up its shipments from ocean vessels at Whittier and Seward. (Current freight rates are shown in Table Two.)

Table Two

FREIGHT RATES — SEATTLE TO FAIRBANKS FOR SELECTED COMMODITIES FEBRUARY 4, 1958

Commodity	*Alaska Steamship and Alaska RR Combined Rate*	*Alaska Freight Lines Barge-Truck*	*Lynden Transfer Line operated Direct Truck*	*Air Freight*
Mining Machinery per ton	$59.12	$70.40	$170-200	$310-380[a]
Groceries	$62.20- 89.90	$67.70- 81.60	$170-200	$380
Vegetables:				
Winter (squash, etc.)	$135.96	$145.00-155.00	$170-200	$340[b]
Potatoes & Onions	$59.74- 84.25		$170-200	$340[b]
Fresh	$85.08-178.19		$170-200	$340[b]
Milk and Cream				$300[c]
Petroleum Products:				
Lube oil, asphalt mix, etc.	$60.77- 79.93	$64.00 69.00[a]	$170-200	$380
Gasoline, benzine, etc.	$62.21- 80.34	$65.60- 70.60	$170-200	$380
Agricultural Implements, including wheeled vehicles	$48.82- 63.45	$70.40	$170-200	$380

[a] 30,000 lb. minimum, will not handle less.

[b] 2,000 lb. minimum.

[c] 100 lb. minimum.

Source: Interstate Commerce Commission Tariffs, February 4, 1958, through the courtesy of Donald J. Osbjornson, Traffic Manager, Pacific American Fisheries, South Bellingham, Washington.

Passenger traffic is handled on a daily schedule to Mount McKinley, Anchorage, Seward, and way points. The new pipeline further diversifies

[24] Jessen's Weekly, October 15, 1953.

the transport picture, its future for civilian use largely dependent on military requirements and policy.

Expansion of the local transportation network continues, including the Steel Creek Road running east from Fairbanks, which is being extended to Chena Hot Springs. This road is passable during the winter months and is scheduled for year-around service by 1960. The road from Fairbanks to North Nenana was completed in 1958 and construction is under way to extend the Elliott Highway from Livengood to Rampart and Manley Hot Springs on the lower Tanana.

The centrality of Fairbanks has made it possible for this small interior city of 13,000 (with an estimated 30,000 within a ten-mile radius) to capture the distribution function for much of the Alaskan interior. Constant improvements in access facilities and in types of carriers have been of marked assistance in the attainment of this role—entrepreneur for the habitable Northland.

In the early stages of settlement, when river boats provided the bulk of cargo movement, only the richer mining claims could be worked economically; with the addition of the Alaska Railroad, large scale operations on lower value claims were possible, thus raising the level of employment and augmenting the economy.

Improved roads, an increase in road mileage, better trucks and cars, additional air fields, and better planes all appeared about the same time. Defense activities which expanded sharply during the war have continued to the present; in addition to military construction now under way in the area, fifty-one Air Force and five Army projects were scheduled for 1960.[25] The functional significance of Fairbanks as an Alaskan center, as always, continues to exceed its status when measured by population alone.

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[25] Employment Security Division, Alaska Department of Labor. "Fairbanks Labor Market Newsletter," January 1, 1960, p. 2.

LAND USE TRENDS IN SAN SEBASTIAN AND MOCA, PUERTO RICO

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The mapping of rural land use patterns is frequently employed as an approach to area analysis. Its value may occasionally be questioned either because the map may be regarded as an end in itself rather than as a tool or because the land use patterns may change rapidly in a dynamic area thereby limiting the usefulness of the map.

If the area is undergoing rapid change, trends in land use are essential in any analysis, and one method of identifying such trends is by determining changes in land use patterns during the period of rapid change. Current patterns can be mapped in the field while prior patterns may be obtained by the interpretation of aerial photographs taken in some selected former year. Comparison of the two sets of mapped data will disclose the location of areas of change and will permit the identification of trends in land use. To achieve a high degree of comparability, both the field study and the photo interpretation should be done by one person.

The municipalities of San Sebastian and Moca in western Puerto Rico meet the criterion of rapid change in land use, the basic pattern having changed since 1930 from the dominance of coffee and food crops to the dominance of sugar cane. Two sets of land use data, the first derived from interpretation of aerial photographs for 1931 and the other mapped in the field in 1951, are employed in this study to identify local areas of change and to aid in determining trends in land use.

San Sebastian and Moca: The Setting

San Sebastian and Moca, comprising about 122 square miles, are located inland a short distance from the west coast of Puerto Rico (Fig. 2, inset). Elevation varies from about thirty feet in western Moca to nearly fourteen hundred feet in eastern San Sebastian, the area serving as a transition zone between the narrow coastal plains and the mountainous interior. Three main physiographic provinces are present: (1) the limestone uplands, (2) the inner plains, and (3) the Cretaceous uplands. Segments of coastal plains occur in northern and western Moca, but the acreages are not significant. The other regions are oriented in an east-west direction (Fig. 1, inset).

The limestone uplands, developed on Tertiary limestone, are subdivided into two parts, a mature karst and a modified karst area. The mature karst, in northern Moca, consists of a band about two and one-half miles from north to south which is generally steep in slope, lacking in surface drainage, and difficult of access. To the east its south facing scarp forms the northern boundary of San Sebastian. The modified karst area in northeast San Sebastian is of moderate relief and typically exhibits shallow sinkholes and

haystack hills. Its thin soils tend to be rocky, and its transportation system is poorly developed.

The inner plains, also subdivided, consist of a limestone lowland, and the Culebrinas Valley. The limestone lowland lies between the modified karst and the south facing escarpment of the mature karst in northern San Sebastian and extends westward through Moca. It is developed on a combination of marl and chalky limestone and is rolling throughout but broken by occasional sharp hills. Surface streams are well developed and the well-drained soils are above average in fertility.

The Culebrinas Valley lies south of the modified karst and the limestone lowland; it consists of alluvium and relict terraces and fans. An escarpment has been developed at the contact point with the modified karst through the erosion of a strata of sand, gravel, shale, and impure limestone, the oldest of the Tertiary layers. The Culebrinas River has cut its valley in shale, tuffs, and ash at the contact between the Tertiary and the Cretaceous upland to the south. The soils, among the best in the area, occupy relatively gentle slopes.

The Cretaceous uplands are a spur of the Cordillera Central, the mountain backbone of Puerto Rico. The Cretaceous materials, largely volcanic tuffs and ash, shale, and some conglomerates have been dissected, leaving an area of steep slopes and V-shaped valleys. Only on the margin of the inner plains to the north is the relief subdued, but nowhere is it level.

The climate is conducive to the production of low latitude crops. Temperatures are uniform and always mild to warm. Precipitation varies with exposure but is ample everywhere except in the mature karst where the porosity of the limestone creates a limiting edaphic condition. Annual rainfall averages vary from about sixty inches to ninety-five inches or more. The soils are diverse, exhibiting wide differences in fertility, depth, erodability, and workability. Those of the inner plains have the highest fertility and occupy the land of lowest slope. Evidence of leaching is widespread, especially in the Cretaceous uplands where lateritic soils are dominant. They are generally of low productivity on steep slopes but relatively fertile on medium to gentle slopes.

The population in 1950 was 56,980, of whom 50,823 lived in rural areas[1] having a density of 416 per square mile. The ownership of farms was widespread. The average size of the 2,708 farms in the area was 25.7 acres,[2] but the median size of farms was small inasmuch as 53 per cent of the total contained less than 9 acres.[3] Farmers, in general, were conservative and used traditional farming methods. Income was derived principally from agriculture with the cultivation and harvesting of sugar cane the primary source of employment; the processing of sugar was the major manufacturing industry.

Patterns of Land Use, 1931-1951

The six generalized land use categories employed in this study are based on the dominant crop or use: (1) sugar cane (occupying over 60 per cent

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[1] U.S. Bureau of the Census, *Census of Population: 1950. Puerto Rico,* Government Printing Office, Washington, D.C., 1952.

[2] U.S. Bureau of the Census, *Census of Agriculture: 1950. Puerto Rico,* Government Printing Office, Washington, D.C., 1951.

[3] Acre is used interchangeably with *cuerda* throughout this paper. An acre is 1.03 *cuerdas.*

of the area); (2) sugar cane (occupying between 40 and 60 per cent of the area); (3) coffee; (4) food crops; (5) pasture; and (6) brush or forest. In all categories other than sugar cane, the dominant crop or use occupied over 40 per cent of the area. In each category there are, however, other minor uses in addition to the one named.

In 1931 the two sugar cane categories occupied about one-fourth of the area; coffee and food crops between one-fifth and one-fourth each; pasture, one-sixth; and brush or forest about one-eighth (Fig. 1). In 1951, the two sugar cane categories occupied about three-fifths of the area; coffee, one-tenth; food crops, one-twentieth; pasture, one-fifth; and brush or forest, about one-twentieth (Fig. 2). The greater part of the expansion in sugar cane area was at the expense of coffee and food crops.

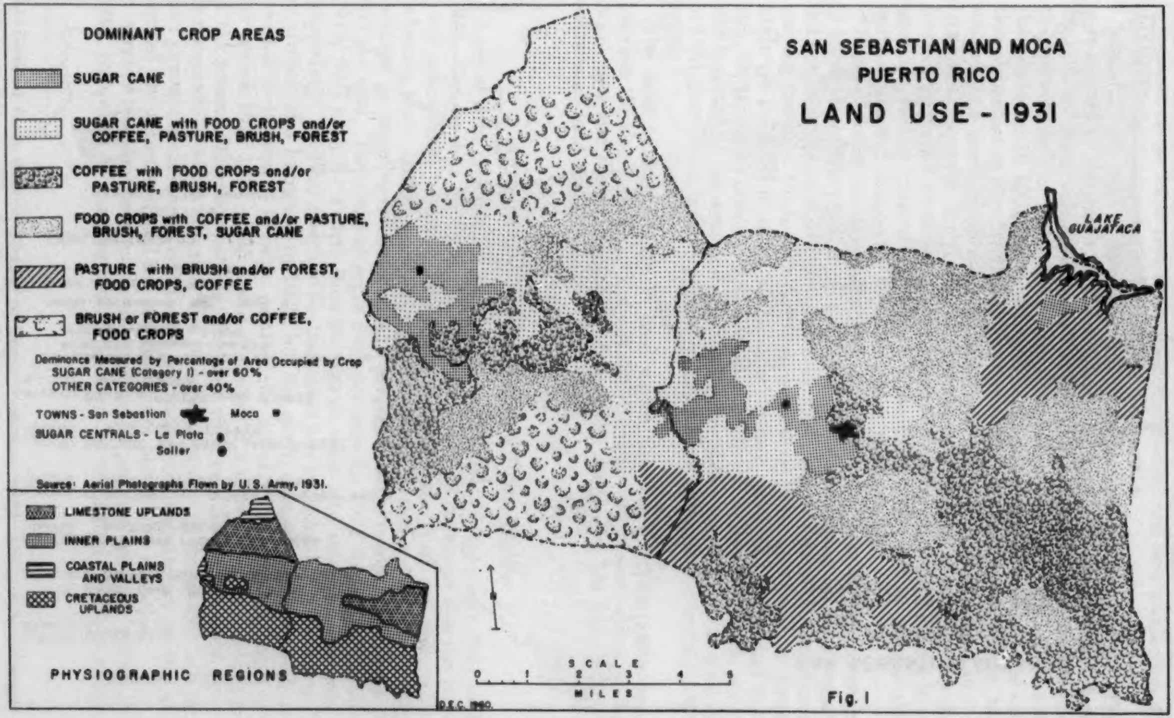
In 1931 category 1 sugar cane was located on the inner plains in western Moca and in western San Sebastian near the Central Plata and adjacent to the Culebrinas River where topography permitted relatively easy transport. There was also a small area south of Lake Guajataca, tributary to Central Soller. In 1951 the area in category 1 was nearly continuous from western Moca to east of the town of San Sebastian. Also, a smaller concentration was located southeast of the town in the Cretaceous uplands, and the area south of Lake Guajataca had expanded somewhat from 1931.

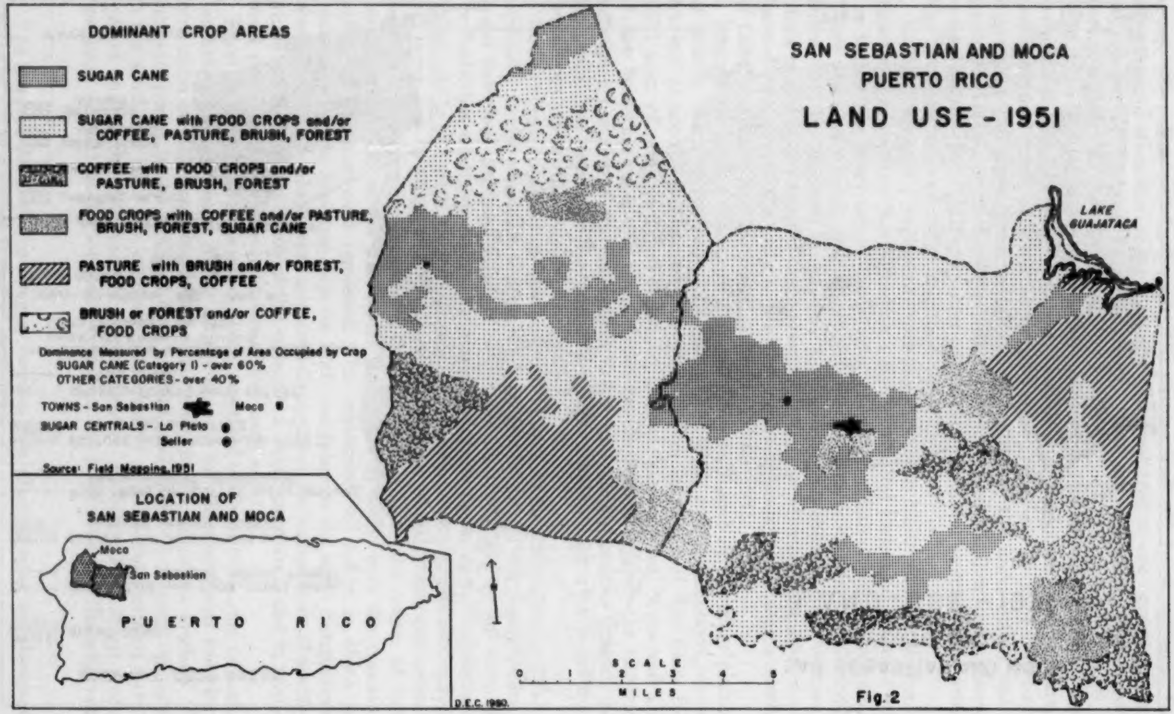
Sugar cane lands in category 2 in 1931 covered much of the inner plains in eastern Moca and western San Sebastian. With minor exceptions, cane was not planted in the eastern two-thirds of San Sebastian at that time. In 1951 areas of category 2 had expanded to cover all of central Moca and all of San Sebastian excepting parts of the modified karst upland, the eastern inner plains section of the Culebrinas Valley, and the Cretaceous uplands in the south. The expansion has tended to be fractional and cane fields are not continuous within the mapped area.

Coffee occupied about 30 per cent of the area of San Sebastian in 1931, especially in the southeast and on the southern fringes of the municipality. Sugar cane had displaced much of this coffee by 1951, leaving the area of concentration about one-half of its former size. Only in the upper Culebrinas Valley and in the more rugged portions of the Cretaceous uplands was coffee still dominant. In Moca, the 1931 land use pattern placed coffee concentrations in the Cretaceous uplands in the southwest and in the center of the municipality north of the Culebrinas River, but in 1951, only the concentration in the southwest remained. The importance of coffee in Moca is understated in the land use data for both years due to the wide distribution of small plantings which were scattered throughout the pasture area of southern Moca, throughout much of the category 2 sugar cane area, and in numerous small patches in the sinkholes of the karst area.

Food crops[4] in 1951 occupied about one-third of their 1931 area in both San Sebastian and Moca. About 30 per cent of San Sebastian was used for food crops in 1931; concentrations were found in the limestone lowland of the inner plains, in the modified karst upland, and in the Cretaceous uplands in the south. In 1951 the category was evident only in the modified karst upland and in the hill lands of the southwest. In Moca food crops were dominant in 1931 in the southeast corner of the karst area and the adjacent

[4] As mapped, the food crop category includes subsistence farming and dooryard gardens as well as a limited amount of truck crops.


SAN SEBASTIAN AND MOCA
PUERTO RICO
LAND USE - 1931
DOMINANT CROP AREAS
SUGAR CANE
SUGAR CANE with FOOD CROPS and/or COFFEE, PASTURE, BRUSH, FOREST
COFFEE with FOOD CROPS and/or PASTURE, BRUSH, FOREST
FOOD CROPS with COFFEE and/or PASTURE, BRUSH, FOREST, SUGAR CANE
PASTURE with BRUSH and/or FOREST, FOOD CROPS, COFFEE
BRUSH or FOREST and/or COFFEE, FOOD CROPS
Dominance Measured by Percentage of Area Occupied by Crop
SUGAR CANE (Category I) - over 60%
OTHER CATEGORIES - over 40%
TOWNS - San Sebastian
Moca
SUGAR CENTRALS - La Plata
Soller
Source: Aerial Photographs Flown by U.S. Army, 1931.
LIMESTONE UPLANDS
INNER PLAINS
COASTAL PLAINS AND VALLEYS
CRETACEOUS UPLANDS
PHYSIOGRAPHIC REGIONS
LAKE GUAJATACA
SCALE
0 1 2 3 4 5
MILES
D.E.C. 1950
Fig. 1


SAN SEBASTIAN AND MOCA
PUERTO RICO
LAND USE - 1951
DOMINANT CROP AREAS
SUGAR CANE
SUGAR CANE with FOOD CROPS and/or COFFEE, PASTURE, BRUSH, FOREST
COFFEE with FOOD CROPS and/or PASTURE, BRUSH, FOREST
FOOD CROPS with COFFEE and/or PASTURE, BRUSH, FOREST, SUGAR CANE
PASTURE with BRUSH and/or FOREST, FOOD CROPS, COFFEE
BRUSH or FOREST and/or COFFEE, FOOD CROPS
Dominance Measured by Percentage of Area Occupied by Crop
SUGAR CANE (Category I) - over 60%
OTHER CATEGORIES - over 40%
TOWNS - San Sebastian
Moca
SUGAR CENTRALS - La Plata
Seller
Source: Field Mapping, 1951
LOCATION OF SAN SEBASTIAN AND MOCA
Moca
San Sebastian
PUERTO RICO
LAKE GUAJATACA
SCALE
0 1 2 3 4 5
MILES
D.E.C. 1950
Fig. 2

limestone lowland and also in the south central hill lands, but in 1951 only a remnant of the karst area concentration remained and new production appeared in the Cretaceous upland in the southeast.

About 27 per cent of San Sebastian was classed as pasture in 1931. This was located to the south of Lake Guajataca, largely in the modified karst area of limestone soils, and in the southwestern part of the municipality on the volcanic soils of the Cretaceous uplands. Moca had only a small area in the southeast. In 1951 the modified karst area contained the only large section of pasture in San Sebastian, about one-third of the former acreage, but much of the southern hill lands of Moca was placed in this category. In the latter area, however, the poor quality of the soil and lack of attention by the farmers precluded intensive use for grazing. Possibly this sector should have been mapped as pasture rather than as brush in 1931, but its use for this purpose was not discernible from the aerial photographs.

Brush or forest was not mapped as a dominant land use in San Sebastian in either year. It is possible that areas eligible for mapping in this category did not exist adjacent to coffee lands in 1931, but definition on the photos was not possible. No large areas were evident in 1951, and brush or forest lands are included in other land use categories, especially coffee and pasture. In Moca the area of karst terrain was classed as brush in both years. The mapping of the area in the southern part of the municipality as pasture in 1951 greatly reduced the proportion of brush or forest land from the 1931 figure.

The most evident change in land use in the San Sebastian-Moca area between the data years was the considerable increase in area occupied by sugar cane and the accompanying decrease in other uses but especially in coffee and food crops.

Agricultural Production and Crop Yields

Lack of data precludes comparison of crop yields for the years 1931 and 1951. Census data for 1929 and 1949 are available, however, and the temporal relationship between the census years and the land use data years enhances their use for purposes of comparison. Between 1929 and 1949, acreages in sugar cane increased 413 per cent, while production increased 503 per cent. The yield of sugar cane per acre for 1929 was 20.9 tons; for 1949, 25.5 tons; for Puerto Rico the figures were 20.9 tons and 29.9 tons, respectively. In 1929 the yield for the island was considerably below normal as a result of a hurricane in 1928, but the storm damage in the study area was not as intense as in other parts of the island. The insular average for the period 1927-1931 of 25.1 tons per acre[5] is a more accurate description of the normal difference between the area yield and the insular yield. The increased yield within the area was probably not due to the quality of new land brought under cane cultivation but rather to such factors as the increased use of fertilizer and the introduction of better cane varieties.

Acreage in coffee declined in the area by 38 per cent between 1929 and 1949, compared to a decrease of 8 per cent for the island. Yields per acre

[5] Derived from data in *Manual of Sugar Statistics, 1948*, Association of Sugar Producers of Puerto Rico, Washington, D.C., 1948.

have constantly remained below the island average. Hurricane damage in coffee was severe in 1928; as a result, the 1929 harvest averaged only 38 pounds per acre for the island and 30 pounds for the study area. In 1919 the figures were 295 and 281 pounds, respectively, and in 1949 insular production was 145 pounds per acre compared to 117 for the study area. The pattern of decrease in both yield and acreage is illustrated by the fact that San Sebastian and Moca contributed 6.5 per cent of Puerto Rico's coffee production in 1919, 6.3 per cent in 1929, 5.4 per cent in 1939, and 4.4 per cent in 1949.

Production decreased for all major food crops[6] in Puerto Rico and San Sebastian and Moca, high ranking among municipalities, experienced a similar decrease. Comprising only 3.6 per cent of the insular area, they accounted for 7.5 per cent of the acreage planted for food crops in 1929, but in 1949 this figure dropped to 4.4 per cent. The absolute decline was 43 per cent for the island and 67 per cent for the study area. Although San Sebastian and Moca surpassed the insular average in yield per acre for all crops in 1929 and for all except corn in 1949, only the per acre yield for yams was higher in 1949 than in 1929.

Insular production showed declines of 49 to 78 per cent for corn, cassava, beans, and sweet potatoes; 31 per cent for yautia; and an increase of 15 per cent for yams. Production in the study area declined 71 per cent to 84 per cent in all except yams, which decreased 44 per cent during the 1929-1949 period. Although the study area still produced more than its share of food crops in 1949, the decline in both acreage and total production was relatively greater than that for the island. A possible explanation is that with declining acreage, crops were relegated to less desirable land where even with an increase in the use of fertilizer and other technical improvements, results were less satisfactory.

Sugar Cane: Changing Production Methods

Changes in farming methods have occurred concurrently with changes in land use patterns, yields, and production. The changes have been minor, however, and have involved the widespread acceptance of practices employed in 1931 by only a few, rather than the introduction of new techniques. Mechanization of farm operations was almost non-existent if measured by the number of tractors in use. In 1929 there were 3 tractors; in 1949 there were 35; but, in total, 1,216 farms were classed as sugar cane farms in the 1949 census. The small size of many farms, the lack of capital, and especially the rugged terrain combine to discourage mechanization. Planting, cultivating, and harvesting techniques, which employed hand labor intensively, changed little in the twenty-year period.

Significant changes did occur in the use of fertilizers and in adoption of improved varieties of sugar cane. No farmers were encountered in the study area in 1951 who did not use commercial fertilizer. Average amounts applied ranged from 600 to 1,800 pounds per acre, but quantities used were decreased by many farmers in years when the price of sugar declined. The

[6] The major food crops include corn, beans, sweet potatoes, yams, yautia, and cassava.

quality of fertilizer also changed during the period and varied considerably from place to place in 1951. Experimentation leading to recommendations of formulas to meet the needs of specific soils was generally lacking in the area but was badly needed.

Of the cane varieties planted in 1931, only one was still used in 1948. POJ 2878 was planted on less than 15 per cent of the acreage in 1931,[7] but in 1948 it occupied over 80 per cent of the acreage.[8] Some farmers were planting higher yielding varieties in 1951, an encouraging practice which should improve production.

A major change in methods of transporting cane from farm to mill occurred between 1931 and 1951. The increase in acreage in sugar cane was due primarily to the building and improvement of roads and to an increase in the use of trucks. In 1931 much of the cane was transported by oxcart and some by pack horses, but in 1951 trucks transported over 90 per cent of the crop and the remainder moved by rail. Nevertheless, oxcarts were still widely used to move cane from the field to a loading dock.

Changes in Patterns of Living

Changes in land use in the study area have been accompanied by changes in living patterns. The relationship between some of the changes is evident but in others the causal factor originated outside the area.

Expansion of the road system and the increased use of motor vehicles greatly enhanced the mobility of the people. In 1931 a trip to town was an event but by 1951 it had become commonplace for most of the rural population. The contacts resulting from increased mobility have helped to create new demands for goods and services and the desire for an improved standard of living has caused many to leave the area for larger Puerto Rican cities or for the United States.

In 1931 laborers on farms producing coffee and food crops were paid in kind, supplemented by nominal cash wages. In addition to food, shelter, and cheap clothing, their requirements were minimal. On coffee farms workers were allocated a plot of ground for their own use, and, when needed, supplementary food was supplied by the owner. By tradition the farm owner recognized a moral obligation to look after the laborers and their families.

The expansion of sugar cane inevitably increased the circulation of money in the area. As jobs paying cash wages increased and the demand for goods and services grew, the traditional relationship between farmer and employee was replaced by a far more impersonal relationship which left the cane worker with no assurance of a job or of any assistance during the dead season between harvests. If he owned or had the use of a garden plot, he could subsist. Otherwise, he might seek temporary work on coffee farms or migrate seasonally to the United States to work as an agricultural laborer. More often he would be forced to rely upon the modest unemployment compensation provided by the insular government and credit extended by

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[7] A. B. Gilmore, *The Puerto Rico Sugar Manual, 1932,* Gilmore Publishing Co., New Orleans, 1932, p. 126.

[8] Edmundo Silva and Guillermo Serra, "Census of Sugar Cane Varieties Grown in Puerto Rico for the 1949 Crop," *Economic Agricultural Series No. 11,* University of Puerto Rico, Agricultural Experiment Station, Rio Piedras, 1950, p. 8.

neighborhood stores.

With the change to a money economy, the standard of living in the area gradually improved. Material wealth increased and generally the people were better housed, better clothed, and probably better fed in 1951 than in 1931. The improvement was not universal, however, and the cash wage worker whose income was irregular might experience a sense of frustration which was much less evident when payment was in kind. On the other hand, the position of the owner-farmer, who might have difficulty accumulating cash but could produce sufficient foodstuffs for his needs, was relatively stable.

Conclusions

1. Data derived from aerial photographs flown in an acceptable prior year, when such coverage is available, may be compared with current field maps to identify specific areas where land use patterns have changed.

2. A major limitation in the use of data from aerial photographs is the difficulty of rating the quality or intensity of a specific land use. Areas devoted to certain extensive purposes are especially subject to some misinterpretation.

3. Photographs permit the measurement of areas which have undergone land use change but supplementary statistical data from census and interviews are essential if the degree of change in actual production is to be substantiated.

4. The implications of land use change are broad. The reasons for change may be obscure and their points of origin distant from the local scene; the effects of change, however, may permeate every segment of the local economy.

AN ALTERNATE APPLICATION OF THE KOPPEN CLASSIFICATION TO EASTERN OREGON

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Among the numerous classifications of world climates developed in the past half-century, the most widely known is the Koppen.[1] This classification, or a modification of it, not only serves as the framework on which the study of climates is developed in many textbooks,[2] but it is also the most commonly used basis for the introductory study of climate in the United States.[3] In the Koppen-Geiger *Handbuch der Klimatologie*, reference is made to the "Oregon climate," so called because it seemed to be unique to the American Pacific Northwest and had its chief areal expression in Oregon,

> . . . the higher plateaus of Oregon, become so cold in winter, –3°C. Jan. (D), and also cool in summer (b), that they are set off as a separate type (Dsb) called the Oregon climate, for it is found nowhere else in the world.[4]

Subsequently, the existence of small areas of Dsb climate have been noted in other locations.[5]

It will be recalled that the symbol "D" indicates a humid continental climate, "s" a precipitation regime in which there is a marked summer drought, and "b" a cool summer.

The latest Koppen-Geiger map[6] shows a considerable proportion of eastern Oregon as having this Dsb climate, a section along the Columbia and Snake Rivers and a larger area in the southeast being classified otherwise.

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[1] Wladimir Koppen, *Grundriss der Klimakunde*, de Gruyter Company, Berlin, 1931.

[2] Among these are Clarence E. Koeppe and George C. DeLong, *Weather and Climate*, McGraw-Hill Company, New York, 1958; Glenn T. Trewartha, *An Introduction to Climate*, McGraw-Hill Company, New York, 1954; Henry M. Kendall et al, *Introduction to Physical Geography*, Harcourt, Brace and Company, New York, 1952; Bernhard Haurwitz and James M. Austin, *Climatology*, McGraw-Hill Company, 1944; Preston E. James, *An Outline of Geography*, Ginn and Company, Boston, 1935, and *A Geography of Man*, Ginn and Company, Boston, 1959.

[3] See L. Dudley Stamp, "Major Natural Regions, Herbertson after Fifty Years," *Geography*, Vol. XLII, Part 4, p. 210, November, 1957.

[4] W. Koppen and R. Geiger, *Handbuch der Klimatologie*, Gebruder Borntraeger, Berlin, 1936, Vol. 2, Part J, p. 195.

[5] An example is John D. Chapman, "The Climate of British Columbia," *Transactions of the Fifth British Columbia Natural Resources Conference*, Victoria, 1952. p. 8.

[6] Wall map, W. Koppen and R. Geiger, *Klima der Erde*, Justus Perthes, Darmstadt, Germany, 1954.

In fact, fully one-half of eastern Oregon is indicated as humid (Fig. 1). Included in this area of humid climate are the Blue, Wallowa, and Ochoco Mountains which are forested and have an appearance indicative of a humid climate, but there are rather extensive areas of plateau and lowland, distinctly arid in appearance, which are also classified as humid. To delimit the areas of humid climate more precisely 55 stations in eastern Oregon were classified according to the Koppen system. Assuming a summer drought, or winter precipitation maximum, (Fig. 2) the area of humid climate appears overwhelmingly dominant in eastern Oregon.

Climatic classification of the plateau country of eastern Oregon as humid seems inappropriate. Neither annual precipitation figures for stations in the area nor the general appearance of the area support such a classification. An alternate application of the Koppen classification, proposed in this paper, would result in most of the eastern Oregon plateau area being classified as semi-arid rather than humid.

The Climate of Eastern Oregon

A study of climatological data for the area is basic to understanding its climate. Four stations were selected to illustrate the character of the climate graphically (Fig. 3). Located near one of the four corners of eastern Oregon, each station has a record exceeding 20 years in length.[7] The following discussion utilizes data for many stations.

Temperatures. The continentality of eastern Oregon is reflected in its temperatures. Mean July temperatures for 55 stations considered are all between 62° and 75° F., with a majority below 71° F. Mean January temperatures are mostly between 21° and 32° F., although a few stations have averages slightly above freezing. Average annual temperature ranges vary from near 35° to 52° F. Highest recorded temperatures for virtually all stations are above 100° F. while lowest recorded temperatures are chiefly in the –20° to –30° F. range. A few stations have recorded minimum temperatures below –40° F.

Precipitation. Annual precipitation for the 55 stations considered varies from 7.7 in. at Umatilla to 19.4 in. at Ochoco. A majority, 47 stations, have less than 15 in. but 23 stations have an annual precipitation of 10 in. or less. Annual precipitation variability for this area is between 15 per cent and 25 per cent.

The precipitation regime of eastern Oregon stations shows lowest mean monthly precipitation in July and August. These months average less than 0.5 in. each for most stations and two stations, Umatilla and Big Eddy, have a 20 year average of .09 in. for July or August.

December or January is the wettest month for most stations, with one to three inches being representative; however, most station records also show May and June as wet months (Fig. 4). In fact May or June is the wettest month at a number of locations, and these months are at least comparable to the wettest month at most stations. There is not, then, a gradual decrease in mean monthly precipitation from the wettest winter month to the driest summer month. Instead, the monthly precipitation either main-

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[7] *Climatic Summary of the United States, Oregon, Supplement for 1931 Through 1952*, Weather Bureau, U.S. Government Printing Office, Washington, D.C., 1956.

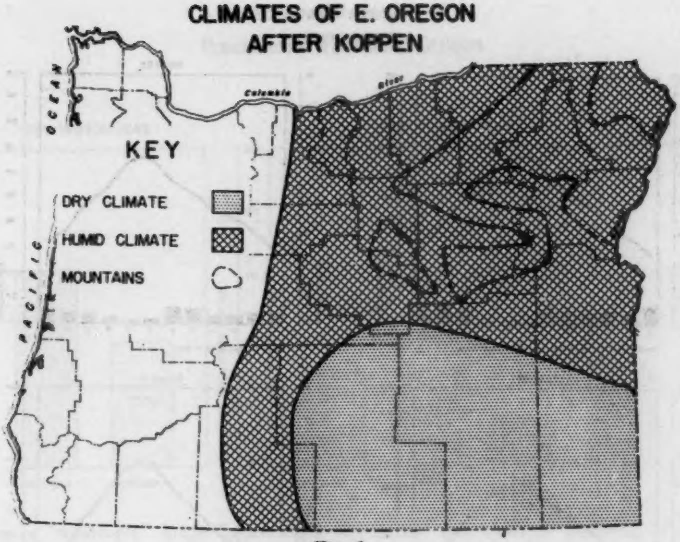
CLIMATES OF E. OREGON
AFTER KOPPEN
Columbia
River
OCEAN
PACIFIC
KEY
DRY CLIMATE
HUMID CLIMATE
MOUNTAINS

Fig. 1

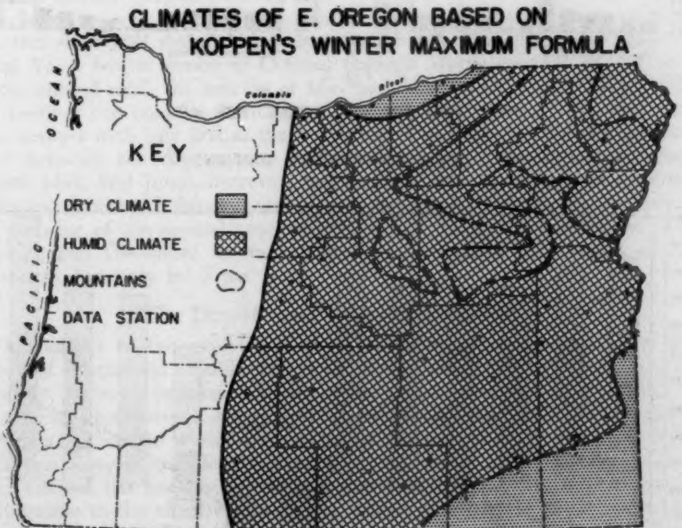
CLIMATES OF E. OREGON BASED ON
KOPPEN'S WINTER MAXIMUM FORMULA
Columbia
River
OCEAN
PACIFIC
KEY
DRY CLIMATE
HUMID CLIMATE
MOUNTAINS
DATA STATION

Fig. 2

EASTERN OREGON

CLIMATIC DATA

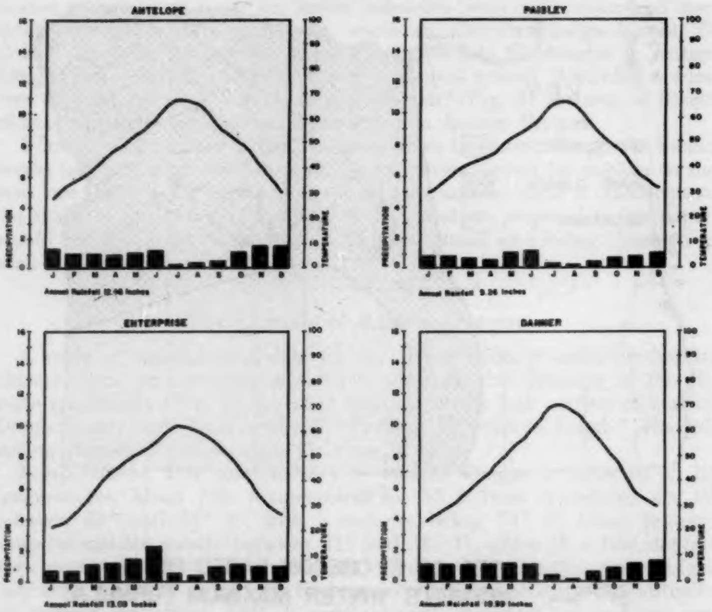

Fig. 3

PRECIPITATION REGIME FOR 48

EASTERN OREGON STATIONS

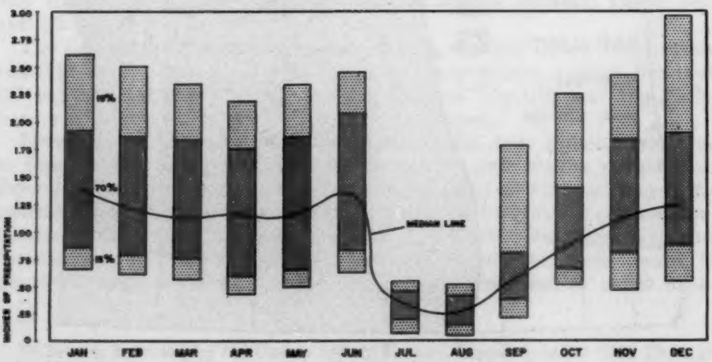

Fig. 4

Seasonal Distribution of
Precipitation in Eastern Oregon

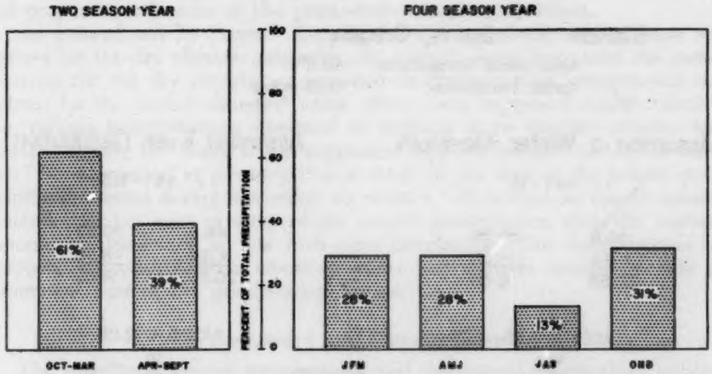

Fig. 5

tains a "relatively" large figure right up to the dry summer months, or it may even rise before dropping abruptly to the summer minimums.

For the purpose of comparing seasonal amounts of precipitation, 20 stations in eastern Oregon were used, 5 from each quarter. The basis of station selection was a comparable length of record. The contrast between the two six-month seasons is evident though less than might be expected (Fig. 5). A winter season of October through March includes 61 per cent of the annual total, the months of May and June being notably responsible for keeping the contrást from being greater. Subdivision of the year into four seasons with July first as the beginning of summer emphasizes the contrast between the dry summer and wetter winter. The resultant spring (April, May, and June), however, turns out to be fully as wet as a winter including January, February, and March, each season having approximately 28 per cent of the annual precipitation. A fall, composed of October, November, and December, averages slightly more humid than either winter or spring, but only by 3 per cent.

The Dry-Humid Climate Boundary

One aspect of the evolving Koppen classification which has been the object of continuous modification is the definition of the dry climates. Admittedly, a knotty problem because of the evaporation factor, the selection of criteria which would adequately define the boundary in such variable locations as those in which dry climates occur proved to be a difficult task. Although Koppen modified his criteria several times, no oompletely acceptable solution has been achieved. According to Koppen, the importance of evaporation to the effectiveness of the annual precipitation is roughly compensated for by making the boundary amount dependent upon both temperature and the season during which most of the precipitation falls. Although it is true that variations in average annual temperature cause

DEPENDENCE OF THE DRY-HUMID BOUNDARY AMOUNT UPON RAINFALL REGIME

Station: **Burns, Oregon.**

Mean Annual Temperature: 46.8°F.
Annual Precipitation: 10.25 inches.

Assuming a Winter Maximum	Assuming Even Distribution
$r = .44T - 14$	$r = .44T - 8.5$
$46.8 \times .44 = 20.59$	$46.8 \times .44 = 20.59$
$20.59 - 14.00 = 6.59$	$20.59 - 8.50 = 12.09$
$10.25 > 6.59$ so	$10.25 < 12.09$ so
HUMID	**DRY**

Fig. 6

CLIMATES OF E. OREGON BASED ON KOPPEN'S EVEN DISTRIBUTION FORMULA

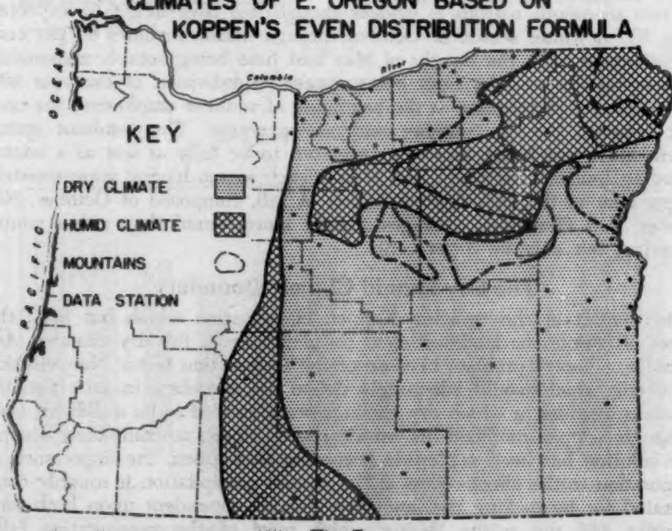

Fig. 7

significant differences in the boundary amount, the factor of seasonal distribution is also important, especially in areas of limited precipitation. The difference in the boundary amount for two stations having annual temperatures of 40° F. and 50° F. would be 4.4 in., assuming a similar precipitation regime, but assuming two different precipitation regimes for the same station boundary amounts differ by 5.5 in. (Fig. 6). The importance of proper classification of the precipitation regime is evident.

As pointed out by James,[8] Koppen did not specifically define these regimes for the dry climates originally. As a result, some have used the same criteria for the dry climates as are used in distinguishing precipitation regimes for the humid climates[9] while others have suggested modifications[10] or various interpretations designed to indicate more specific criteria. Included among the latter is the suggestion that the phrase "chiefly in winter" be interpreted as meaning that at least 70 per cent of the annual precipitation occurs during the winter six months.[11] If neither six month season includes 70 per cent or more of the annual precipitation, then the regime should be designated as one with even distribution. This interpretation is especially applicable in a situation where intermediate seasons include a dominant part of the precipitation regime.

Summary and Conclusions

The severity of winter temperatures and the annual temperature ranges of eastern Oregon justify the continentality signified by the symbol "D". However, these same temperature features are common to mid-latitude dry climates.

Annual precipitation figures comparable to those typical of eastern Oregon occur in some areas of "D" climate, but where that low they are usually accompanied by lower mean annual temperatures. Annual precipitation in eastern Oregon is marginal in amount for the "D" category, at least as typical of mid-latitude dry climates as of "D" climates.

The factor which causes so much of eastern Oregon to be classified as humid is the precipitation regime. Using Koppen's formula for a winter maximum, only four stations out of 55 in eastern Oregon are classed as dry (Fig. 2). Using the formula for even distribution, 40 of the same 55 stations classify as dry (Fig. 7) and the majority of the others are in or adjacent to either the Cascades or the Blue-Wallowa Mountain group.

There are two main reasons for advocating the use of Koppen's even distribution formula for eastern Oregon:

1. The dry season begins abruptly and lasts only three months. Since the remainder of the year has a fairly even distribution of precipitation, this short dry season should not dominate the entire precipitation regime.

2. Definition of the precipitation regime as one of summer drought im-

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[8] James, 1935, *op. cit.*, p. 373.

[9] Trewartha, *op. cit.*, pp. 381-383; Haurwitz, *op. cit.*, p. 112.

[10] Richard J. Russell, "Dry Climates of the United States," *University of California Publications in Geography*, Vol. 5, 1931.

[11] James, *op. cit.*, p. 373; Alfred H. Meyer, "An American Adaptation of the Koppen Classification of Climates," *Papers of the Michigan Academy of Science*, Vol. 23, 1937, pp. 361-366; Koeppe and DeLong, *op. cit.*, p. 194.

plies a winter maximum according to the Koppen system. A precipitation regime identified as one with a winter maximum should have that season clearly dominant, but this is not the case in eastern Oregon. Spring and fall are fully as wet as winter.

Dry climates are those in which evaporation exceeds precipitation. Many factors, including natural vegetation, land use, the over-all appearance of the area, as well as climatic data indicate that this is the case for most of eastern Oregon. Use of the even distribution formula rather than that used with a winter precipitation maximum results in a climate classification for the area which agrees with its other characteristics.

AN EVALUATION OF OASIS AGRICULTURE

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The rise of commercial farming in our western oases has been controversial from the very beginning. To some observers, American oasis agriculture has always been questionable because of small acreages, high operating costs, the meagerness of water, competition with identical products of regions where farming expenses are lower and water supply more plentiful. In rebuttal, proponents of western desert agriculture point to the phenomenally high per-acre yields of the oases, new farming technologies, and growing food needs of an increasing population as strong justification for even greater irrigation developments in the future.

Whatever the outcome of this debate, and there is still little general agreement, a critical but unbiased view of all irrigation developments, planned and existing, is essential. Desert farming, by its very nature, faces more problems than humid agriculture; stakes are higher, losses in a failing irrigation economy are many times as heavy, yet profits in a successful one are often spectacular. Periodic assessments of the worth and potentials of the various oases not only help to reduce farming failures but also insure a greater number of productive enterprises. One of the best opportunities for a critical evaluation of oasis farming is offered by the deserts of southeastern California, which include a good part of the driest section of the United States as well as some of the most publicized examples of oasis farming. While a paper of this length cannot approach the comprehensiveness needed for a complete economic evaluation of such a large area, the theme can be demonstrated in a general way by applying three basic criteria: physical productivity, availability of water, and economic justification.

Productivity: Great or Small?

One of the single most important measures of the effectiveness of California oasis agriculture is its productivity. Acreage is a primary index, and there is general agreement that its present area is indeed small. The approximately 700,000 acres of watered land in the southeastern dry region is just 3 per cent of the total irrigated land of the western states in which most of the country's irrigation is practiced. Although a little higher in California, this area still comprises about 10 per cent of all the irrigated land in the state. Furthermore, these 700,000 acres are but a fraction of the 27,000,000 acres encompassed by the southeastern desert, over a quarter of the total area of California.

If lands that are potentially irrigable (Table One) are included the acreage picture is startlingly different and at first glance would seem to justify some of the most roseate views of the irrigation protagonists. Almost 3,000,000 acres, more than four times the amount of currently irrigated land, are available. In California, only the San Joaquin Valley has as much potential

acreage. On a national scale, this amount represents 13 per cent of all the potentially irrigable land in the West; it rises to around 18 per cent if current and potential irrigation areas are combined.

Table One
IRRIGATION IN THE SOUTHEASTERN DESERT: PRESENT AND POTENTIAL[1]

Oasis[2]	*Currently irrigated*	*Potentially irrigable*	*Total*
Imperial Valley	477,700	487,600	965,300
Palo Verde Valley	76,000	28,000	104,000
Antelope Valley	74,000	510,000	584,000
Coachella Valley	54,000	234,000	288,000
Mojave Valley	14,000	420,000	434,000
Owens Valley	12,000	143,000	155,000
Death Valley	11,000	871,000	882,000
Bard Valley	5,000	10,000	15,000
Twentynine Palms	2,000	139,000	141,000
Lanfair Valley	——	185,000	185,000
Total	725,700	3,027,600	3,753,300

[1] Based on a variety of sources: Annual reports of the Imperial, Coachella, and Palo Verde irrigation districts; Annual Crop reports of Los Angeles, Imperial, and Riverside counties; Bulletin No. 2, Vol. 1, *Water Utilization and Requirements of California*, by the California State Water Resources Board; *Know California's Land*, by L. R. Wohletz and E. F. Dolder; *Report on the Contribution of the All-American Canal System to the Economic Development of the Imperial-Coachella Valleys, California, and to the Nation*, by the Bureau of Reclamation, U.S. Dept. of the Interior; and a personal communication from Mr. Otis A. Harvey, Farm Advisor for Riverside County, January 11, 1957.

All statistics are approximate. Those for the Imperial Valley are as of 1955. Currently irrigated acreages for the Palo Verde, Bard, and Coachella valleys are for 1954. All other statistics are based on the average for the 1948-51 period.

[2] Some oases have been grouped within hydrographic units for statistical convenience. This is especially true for Death and Lanfair valleys and the Twentynine Palms area where tracts of potentially irrigable land are particularly numerous, scattered, or both. See also Figs. 1 and 2.

Growing seasons range from a meager three to a moderate seven to eight months in well over half of the potentially irrigable lands (Fig. 1). Only in the extreme southeast are both lower latitudes and elevations combined to produce the longer growing seasons and greater heat which many are wont to apply to all of the southeastern desert (Fig. 2). This "low desert" portion, however, is no more completely free from physical limitations than the "high desert."[1] Sandy soils, a major problem in the utilization of most potentially irrigable land, cover extensive areas on the eastern and western sides of the Imperial Valley, as well as sections fringing the Colorado River, both in the United States and Mexico. They also lie at higher levels than the presently irrigated lowlands, in some cases up to eighty feet or more along the western side of the Palo Verde Valley. Having fairly smooth surfaces and breaking off to the lower lands in escarpments, the landforms on which these soils rest look like terraces but are commonly called "mesas." Actually, they are remnants of an older floodplain of the Colorado. Although the mesa floors are

[1] The isoline on Figures 1 and 2 separating the low and high deserts marks the area of eight-months growing season.

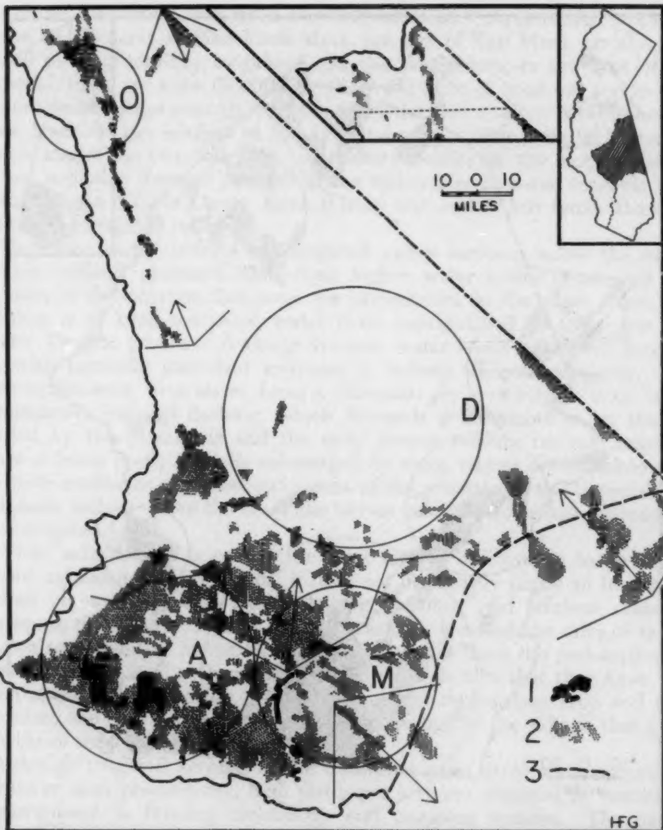

Fig. 1

generally covered with desert pavement, it is so thin that it can be easily mixed with the soil by cultivation and presents no problem in cropping. Unfortunately, the soils drift badly. They are also extremely porous, the Bureau of Reclamation finding in tests that some mesa soils require at least ten times as much water as those of the well-established oases. Labor costs are also high. Little of the mesa land bordering the Imperial Valley is being released as yet by the Bureau, pending conclusive proof that settlers will have a reasonable chance of success.

Some mesa soils are better than others but they occur in numerous and small patches which make efficient irrigation distribution systems impossible. If a well integrated net is desired, poorer land must be incorporated into the scheme. More recently, an attempt was made to amend that part of the Desert Land Act (1877) which permits each person to make an entry on only one, undivided unit. The amendment would have allowed the settler to develop scattered tracts of land which individually are too small for

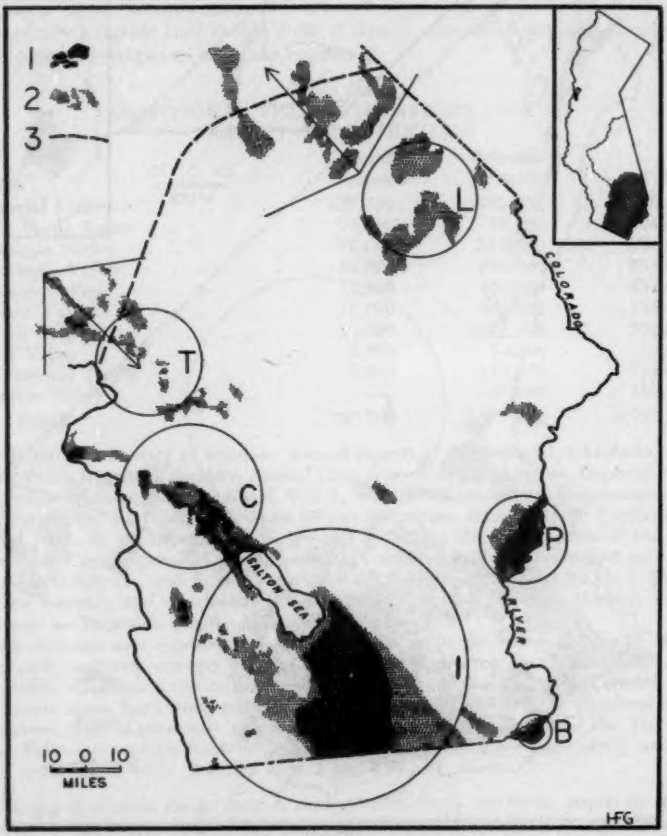

Fig. 2

proper utilization, but which are close enough together to be managed satisfactorily as an economic unit. The bill was passed by the Senate in 1956[2] but failed through House inaction in 1957.

A striking example of the handicaps of high soil porosity and areal fragmentation is the mesa immediately east of the Imperial oasis, East Mesa, which comprises 225,000 acres. Of this total, only 35,900 is considered within "potential development units." Half of this potential is actually very poor land but must be incorporated into the distribution system to make it economically feasible. Thus, only about 18,000 acres, or just 8 per cent of

[2] U.S. Congress, Senate, Committee on Interior and Insular Affairs, *Desert Land Entries on Disconnected Tracts*, Sen. Report 2271, to accompany S. Bill 3512, 84th Cong., 1st Sess., June 19, 1956 (Washington: Government Printing Office, 1956).

the entire East Mesa, are rated fair irrigable land.[3] Approximately 13,000 of the 24,000 acres on Pilot Knob Mesa, just east of East Mesa, are also estimated to be potentially irrigable.[4] On the West Mesa, to the west of the Imperial, there are some 65,000 acres believed to be of good soil and in contiguous bodies large enough to justify more detailed study.[5] Altogether, the mesa lands on the borders of the Imperial offer a little over 96,000 acres which might be irrigated with satisfactory results in the not-too-distant future, not more than 20 per cent of the technically potential irrigable land in that region (Table One). Even this 20 per cent is less fertile than the lower-lying irrigated soils.

The more loamy soils of the irrigated valley bottoms below the mesas are not without problems since their higher water tables create just the opposite of the situation that faces the agriculturist on the mesa. Here, the problem is to keep too much water from accumulating in the upper soil layers. Despite extensive drainage systems, water levels have been increasing with naturally attendant increases in salinity and waterlogging. The oasis irrigationist, in a sense, faces a dilemma: to over-irrigate is to invite salinification; yet soil flushing, which demands a fifth more water than is needed by the plants,[6] is still the only proven remedy for salt removal. Lines of fence posts, partially submerged by rising waters of the Salton Sea, are mute evidences of the serious nature of the situation in the Imperial and Coachella valleys where the bowl-like terrain provides no escape for seepage from irrigated lands.

While salinification is one of the most serious indictments to be raised against agriculture in arid lands, it does not necessarily imply an inevitable decline in oasis farming. Deep plowing, flushing, and efficient drainage systems in the California oases have increasingly lessened the ratio of salinification to amount of irrigation. More positive has been the reclamation of several tracts of land so heavily impregnated with salts that they have had to be abandoned. Rice has proved an excellent reclamation crop and in a few cases one crop was sufficient to remove enough of the salts so that good growths of milo could be made later.

Although irrigated acreage of the California oases gives an unimpressive picture of oasis productivity, high yields per acre are obtained by numerous improvements in farming technology and cropping systems. The desert region has shared with the rest of the country the tremendous advances in farm mechanization, soil conservation practices, plant selection and animal breeding, use of fertilizers, as well as processing and marketing procedures. Few agricultural areas of comparable size expend as much capital to accomplish these improvements as do the oases of southeastern California.

Inter- and multiple-cropping, always a part of the desert farming system,

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[3] U.S. Bureau of Reclamation, *Report of Repayment Ability, Imperial East Mesa, All-American Canal Project, California*. March, 1948 (Boulder City, Nevada), p. 3.

[4] *Ibid., Land Classification Report: Pilot Knob Mesa Unit, Imperial Division, All-American Canal System, California Boulder Canyon*. April, 1950 (Yuma, Arizona), p. 2.

[5] *Ibid., Major Irrigation Developments in Region 3*. November, 1951 (Boulder City, Nevada), p. 10.

[6] N. L. McFarlane and G. L. Winright, *Desert Agriculture*, University of California, College of Agriculture, California Agricultural Extension Service Circular 176 (Berkeley, 1951), p. 9.

is practiced mainly in the low valleys of the Imperial, Coachella, and Palo Verde, although a little of this intensified cropping is carried on in the higher and more northerly valleys of the Antelope and Mojave River. Intercropping of dates and citrus has been a tradition in the Coachella, while interplanting of grains and grasses with higher-income crops is becoming increasingly popular in all of the warmer oases. An example of this last combination is the planting of barley and purple vetch in vineyards, thereby providing much-needed green manure and preventing blowing of the soil. Consecutive planting of two or more crops in the same year is even more characteristic of California oasis farming. Much of the land produces three truck crops in two years. Where field crops compete with truck, the land may be planted to one crop of truck and one of sugar beets within the same year. The outstanding example of multiple cropping is provided by alfalfa, an oasis staple. In the Imperial Valley alfalfa commonly yields six cuttings a year, even though held dormant during a part of the summer. On a year-around basis, the number is as high as ten or eleven. The total of "crop acres" for the warmer oases is therefore far more extensive than the irrigated acreage. In the Imperial, it is 40 per cent more; the Coachella, 25; the Palo Verde, 10. Together, they represent over a third again as much land used for agriculture as is indicated in conventional acreage figures.

An even more impressive indication of the production intensity of the California oases is its monetary value. It can be discussed more profitably, however, under a subsequent point.

Water Supply: Inadequate or Abundant?

There is a tendency to oversimplify the problem of water supply in California oasis agriculture, but it is a mistake to assume that the unavailability of water, as such, is the most serious issue. There is still sufficient Colorado River water available not only for those desert areas presently irrigated but for much of the potentially irrigable land bordering them—even considering the effects of a future Supreme Court decision adverse to California in that state's legal battle with Arizona over rights to Colorado water. Ground water supplies, while limited, are still important. In the Antelope Valley, where they are most tapped, amounts are considered adequate for many years to come despite a steady lowering of the water table since World War II. Taking into account other sources of water available to the state, the situation is even better. The total water supply of California is estimated to be well ahead of projected demands for both urban and agricultural use.[7] In agriculture, these appraisals show that the state's currently irrigated area could be tripled, a larger acreage than the amount believed irrigable on the basis of the inherent physical qualities of the land (i.e., soils, terrain, drainage). Coincidentally, this would satisfy the total water demands of agriculture in the southeastern desert of California, were all potentially irrigable lands to be watered.

However, this favorable picture should not overly encourage the optimist on the future of desert farming. While the California desert region does not

[7] California State Water Resources Board, *Water Utilization and Requirements of California*, Bull. 2, Vol. 1 (Sacramento: State Printing Office, 1955), p. 27.

lack water sources, some of them lie well beyond its borders. Irrigation of all desert tracts capable of agriculture would be impossible without importing water from the more humid parts of the state; the water is there and technological means for obtaining it already exist. The question is not so much a shortage but rather the ability of the potential reclamation areas to pay for it.

The "financial availability" of water is governed not only by distance but by several other items, the individual importance of which vary with the particular area. On the high desert, it is distance and elevation that make any large irrigation growth in the near future improbable. Highly significant is a recent economic survey of the ability of the Antelope and Mojave River valleys to pay for imported water. It would be brought from the northern Sierra within the framework of the contemplated Feather River Project and would be applied to 550,000 acres, some 75,000 acres more than all the irrigated area of the Imperial Valley. The gist of the report is that such a project would be highly uneconomic, the farmers not being able to make the $25 to $45 revenue per acre-foot believed necessary to cover costs of bringing water to that part of the state.[8] Unlike the lands of the low desert to the south, elevations average more than half a mile above sea level in the Antelope-Mojave section with a resultant growing season of only a little over seven months. Increasing latitude reinforces the temperature limitations of even higher elevations farther north. The financial inability of oases in the high desert to expand their acreages is a reflection of the principal geographic mismatching facing California desert agriculture: the greatest part of the potentially irrigable land is in the area of lowest thermal efficiency.

On the other hand, the best case of geographic coordination obtains in the low desert. It was the remarkably good luck of the Coachella, Imperial, Palo Verde, and Bard valleys to find themselves not only closer to Colorado River water but also with a terrain that made pumping costs almost trivial. Coupled with the valuable off-season crops that are possible only in these areas of longer and hotter growing periods, it is not difficult to see how farmers in these favored oases have been able to pay the high irrigation charges. But if distance from good water sources is not the handicap that it is in the high desert, elevation is still a problem for the mesas, the areas where future irrigation will have to take place. Pumping costs involved in lifting water from the presently irrigated valley floors over the escarpments to the mesa surfaces would be formidable. Elevations are as high as 300 to 400 feet in some sections of the Imperial area. Water requirements would be far greater than in the present oases because of the sandier soil. Other necessary intensive farming practices, such as the erection of windbreaks to check blowing soil, the construction of "brushing shields" to reduce the damage of drifting sand and to conserve heat for plants, and the extensive use of portable sprinkler systems to irrigate many scattered tracts, would add still further to the expense of mesa farming. Many of these costs are easily borne by present oases, but their operation in conjunction with the

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[8] Bechtel Corporation, *Report on the Engineering, Economic and Financial Aspects of the Feather River Project to the Joint Committee on Water Problems, California State Legislature*, December 31, 1955, p. 120.

additional expenses of mesa agriculture would make farming hazardous at best.

The financial availability of water to the oases is also being increasingly conditioned by the ability of other rural and urban regions to pay for the same potential supplies. Few agricultural regions are less able to pay for new water supplies from humid northern California than are the southeastern desert lands, but the intensive farming regions of the Central Valley and central and south coasts are easily capable of "paying their way." Many of the small and less economically valuable agricultural lowlands of northern California have the advantage of proximity to water sources. Of even greater portent for the future of the oases is the rapidly growing financial power of California urban areas, particularly the south coast. The above mentioned report with regard to the ability of the Antelope Valley to pay for Feather River water suggested that the amount designated by the state for the desert could still be profitably used—by the coastal urban areas. Significantly, practically all of the Feather River water envisaged for southern California in the state plan is also for the urban agglomerations. There is even a probability that southern California cities, with their expanding domestic and industrial needs, will some day have to purchase the water rights of the low desert oases to Colorado River water, the same procedure followed by Los Angeles in the Owens Valley oasis a half century ago. The oases are presently allotted about 75 per cent of the Colorado River water available to California under the Colorado River Compact and Boulder Canyon Project Act.[9]

Cities have an even greater financial advantage in obtaining water from less conventional sources. Desalinized sea water is still short of economic feasibility even for cities, and obviously even more expensive for oasis farmers. Charges for reclaimed sea water, on the basis of research as of December, 1956, would have been approximately $100 an acre-foot; during the same period, the Imperial Valley farmer paid $67 for a similar amount of Colorado River water.[10] Should the economic barrier on desalinized sea water ever be broken, however, there is a probability that the inland sources of supply now used by the coastal cities could be transferred to all of the state's agricultural lands, including the desert. Urban areas would also be better able to afford reclamation of brackish waters, although the lower salt content—only about one-tenth that of sea water—and the easy accessibility to large amounts of saline marshes would make the low desert oases much more competitive.

Economic Justification: Subsidy or Market Need?

That the availability of water is ultimately dependent upon the ability of the desert region to pay for it leads to a basic question underlying oasis agriculture, an issue more critical than water itself: can desert farming in California produce enough to compensate for the high charges necessary to import water? Implied in this query is still another, involving the broader

[9] Colorado River Board of California, *California's Stake in the Colorado River* (3rd ed. rev.; Sacramento: State Printing Office, 1954), p. 14.

[10] Personal interview with Mr. Harry F. Blaney, Irrigation Engineer, Division of Irrigation and Water Conservation, U.S. Department of Agriculture, Los Angeles, December 27, 1956.

national picture: can this production satisfy a genuine economic need, or must it be artificially induced?

Oases can support present water charges, particularly in the low desert where temperature conditions are at their best. Opponents of new irrigation developments commonly charge that American oasis agriculture is subsidized, pointing out that most of its products compete on the national market with similar ones raised in humid areas at far less cost. Without going into the merits of such an argument as it applies to American oasis farming, it can be shown that production of the low desert oases is not only valuable to the local areas but also to the country.

The Imperial Valley, easily the largest of the irrigated areas in southeastern California, owes its rapid growth largely to its off-season crops. Like the rest of the low desert, the southern California littoral, Florida and the Gulf Coast in the East, the Imperial is one of those few favored areas in the United States which has a mild winter when most other sections must reduce, or stop entirely, their crop output. Lettuce, melons, and carrots are but a few of the several types of winter vegetables shipped to eastern markets by this area, the foremost vegetable producer of the state. The same situation is found in other low desert oases, but to a lesser degree. Exotic crops, those which command a strong position on the market by their very nature, also add to the high value of oasis agricultural production. Dates are most lucrative, 90 per cent of the American acreage being in California and with most of the acreage in the Coachella. Grapefruit is a high quality item in both the Coachella and Imperial valleys. "Mediterranean," or *Vitis vinifera*, grape types are becoming more important, although they are produced only as early table grapes because of the competition of other grape areas during the summer. Oranges are grown commercially to some extent in the Coachella.

The great part of this specialty crop production goes to eastern markets. But certain fundamental changes now taking place in the production structure of oases reflect the growing importance of a local demand—the burgeoning California population. The national reputation of the desert's winter vegetables and some of its fruits might easily convince the casual observer that these oases grow little else. The reverse is actually the case; except for the Coachella, field crops have always greatly exceeded truck and tree crops in the use of the land (Table Two). Field crops are dominant since they

Table Two

CROP ACREAGES IN THE LOW DESERT OASES*

Oasis	*Crop type*	*Year* 1940	1955
Imperial	**Field**	**545,535**	**677,562**
	Truck	**156,342**	**88,449**
	Tree	**8,674**	**3,657**
Palo Verde	**Field**	**42,742**	**62,227**
	Truck	**836**	**17,327**
	Tree	**105**	**30**
Coachella	**Field**	**2,830**	**23,237**
	Truck	**4,555**	**10,569**
	Tree	**8,968**	**18,749**

*** Extracted from annual reports of the Imperial and Palo Verde irrigation districts and annual crop reports of Riverside County. Statistics for the Palo Verde in 1940 taken from the Federal Census.**

All acreages are in crop acres, except for those of the Palo Verde in 1940. The latter refer to the acreage in crops at the time of enumeration.

are vitally needed in an indirect way by both California and extrastate markets. Hay, grain (stubble), and leguminous crops are not only natural rotation partners for the vegetable specialty crops but also good cover crops for orchard areas, providing the green manures so vitally needed by desert soils as a source of plant nutrients. Certain plants, especially alfalfa and sesbania, also add legumes to the soil and increase irrigation permeability by breaking up the soil with their tap roots.

Field crops also contribute heavily to that portion of the oasis economy having particular import for the local California market. This demand area not only gets the benefits of better fruits and vegetables through the oasis farmer's extensive use of field crops but also depends indirectly upon the field group for its meat and dairy products. California has been a beef- and pork-deficient area for some time, and with increasing demands will probably continue to be a deficit area. The state now produces enough fluid milk products for its own needs, but continuing population growth is expected to create a deficit by 1975.[11] In response to these needs, the livestock industry has expanded greatly in the warmer oases, in turn enlarging its forage requirements. Alfalfa is the most popular feed, occupying about two-fifths of all crop acreage. Sorghum also provides a large amount of silage for both cattle and hogs. Barley, the most important cereal crop grown in the desert, is sold mainly as a feed grain. In all, about 100,000 beef cattle and 200,000 sheep are brought to the oases from the range each year for winter feeding,[12] not to mention the several thousands of hogs and dairy cows raised there.

The growing demand by the California market for livestock and livestock products—coupled with recent heavy cotton plantings—has now enabled field crops, for the first time since the beginning of agriculture in the low desert, to exceed all other major crop groups not only in acreage but also in value. Only in the Coachella do field crops still fail to lead, and that only in value of production. An additional "revolution" in oasis production structure is well shown by statistics from the last two agricultural censuses for the Imperial Valley (Table Three). Gains in value of livestock and livestock products have been second only to those in field crops, with the result that

Table Three

VALUE OF FARM PRODUCTION IN IMPERIAL COUNTY*

Farm products	*1949*	*1954*
Field crops	$29,123,329	$54,610,636
Truck crops	29,604,562	21,503,944
Tree crops	122,900	361,082
Livestock and livestock products	15,711,147	32,183,120
Total	$77,203,593	$109,386,713

* U.S. Bureau of the Census, *1954 Census of Agriculture. California*, Vol. I, Pt. 33 (Washington: Government Printing Office, 1956), pp. 68-69.

livestock and livestock products have also forged ahead of the traditionally more profitable specialty crop group. Only in the Coachella, animal industries still fail to exceed fruits and vegetables in revenue.

There is, therefore, little question as to the economic justification of pres-

[11] R. L. Simmons and R. G. Bressler, "California Dairy Industry, 1975," *California Agriculture*, 12 (November, 1958), 2.

[12] McFarlane and Winright, *op. cit.*, p. 52.

ent oasis production in California. All but two of the seven counties which have some of the oasis agriculture of southeastern California rank in the top ten of the nation in value of all farm products sold. Imperial County, the only one wholly in the desert, ranked seventh in 1954, moving from eighth position in 1949.[13]

As to whether future areal expansion of oasis agriculture can justify expanded water developments, the outlook is much less optimistic. The great bulk of potentially irrigable desert land is in the high desert where growing seasons are short and distances from large water supplies are great. There is no chance for these oases to produce the winter specialty crops that have made the low desert oases prosperous and which would cover the higher expenses attendant to a more intensive and expanded agriculture. The Antelope Valley, the only oasis of any note in the high desert, grows practically none of the subtropical crops so typical of the more southerly oases. The hardier field crops are therefore even more important in the production picture of the Antelope, but their total sale value—$7,127,910 in 1954[14]—is still a pittance of that paid for field crops in the warmer areas. To match the Imperial at its present rate of profit, the Antelope would need to have approximately a million irrigated acres available, almost fourteen times its current 74,000 and half again as much as the presently irrigated acreage of all the oases of southeastern California. Even the Coachella Valley, with just one-third of the irrigated area of the Antelope, produces almost three times as much agricultural revenue. This is not to say that the Antelope Valley is a meager producer, for it is a major supplier of alfalfa, grains, and other products to the nearby Los Angeles market to the sum of over $8,000,000 annually. But, in an area where physical conditions are highly restrictive to farming in the first place, sizable revenues become more of a necessity than a bonanza. Potentials for irrigation expansion in most other parts of the high desert are still less promising because of even poorer local water supplies, lower temperatures, or both.

Development of potentially irrigable lands in the low desert also faces financing problems. Sandy soils and higher surface elevations guarantee much higher water costs than charges for irrigation in the present oases—when and if the mesas are reclaimed. The expansion outlook is not quite so bleak, however, as in the high desert. Temperatures for crop growth are at least milder and the mesas are close to a large supply of water. Even the very disadvantages of the mesa lands provide some minor advantages. Their higher elevations capitalize on air drainage, so that growing seasons in several sections are actually slightly longer than those of the Imperial, Coachella, and Palo Verde valleys. Sandy soils encourage high water loss through rapid percolation but they also discourage waterlogging which eventually leads to salinification. Sandy soils are also warm, an advantage in the marketing of winter vegetables.

Off-season vegetable crops appear to provide the best opportunity for offsetting the potentially high farming costs of the mesas. Specialized fruits offer another opportunity for profitable agriculture, although competition

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[13] U.S. Bureau of the Census, *1954 Census of Agriculture. Ranking Agricultural Counties*, Vol. III, Pt. 2 (Washington: Government Printing Office, 1956), p. 3.

[14] Los Angeles County, Office of Agricultural Commissioner, *Plant Crop Report —Antelope Valley District—1954*, p. 1. (Mimeographed.)

from other areas having lower production costs must be expected. Lemons and grapefruit would actually grow better here than in the Imperial Valley and the Palo Verde and Yuma (Arizona) oases along the Colorado River. Lemons in the desert produce only during the winter, but this poor timing could be mitigated by concentrating on lemon products, a rapidly growing industry. Whether the higher costs of water and pumping would not hurt a budding citrus industry in competition with more established regions like Florida, southern coastal California, and even the Coachella, is still, however, a serious question. The market situation is even more restricted for dates, another fruit which could be grown on the mesas. The Coachella, which produces practically all of the nation's dates, is itself surpassed in the American market by Iraqi imports. Early season table grapes could do fairly well on the mesas, but the number of heat units required by the vine is not quite that of the Coachella where grapes are becoming an ever more important crop. Mesa land could be used advantageously for growing forage crops and grazing livestock; the California market for livestock and livestock products is far from saturated. Without fruits and vegetables and their higher income intensities, however, field crops would not justify extensive reclamation efforts.

A more definite idea of the economic capabilities of these crops will be obtained in the near future when new irrigated farms on the Palo Verde mesa begin to produce. This is, as yet, the only irrigation development of note on the California mesa lands.[15] It will eventually add 16,000 acres of farmland to the currently irrigated area of the Palo Verde oasis. Alfalfa and citrus are already being planted on early farms, as well as grapes, and potatoes and other vegetables.[16]

Conclusion

Several of the answers to questions concerning the practicality of California oasis agriculture have been answered either tentatively or indirectly. Some queries have produced several answers, depending upon the particular area and also the imponderables of the future, such as new farming techniques and changing market demands. Perhaps the best single conclusion that can be drawn from this brief view is that irrigation in southeastern California has not been the agricultural revolution portrayed by some enthusiasts, nor certainly the wasteful economy envisioned by the more rabid irrigation opponents. Most of the desert region is still idle land and will undoubtedly remain so in the near future; yet the production of the oases has been heavy for their small areas and the potentialities for increased production seem good. The lack of ready-made answers to all our questions on the value of oasis farming is, of course, no indictment of the utility of these studies; they actually emphasize the need for more of them.

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[15] Extensive plantings of lemons have been made in the last few years on the Yuma Mesa, the only sizable Arizona counterpart of the California mesas and located south of the city of Yuma. Smaller acreages are cultivated to grapefruit and oranges, as well as a few acres of tangerines and limes, but their quality is not as good. R. H. Hilgeman and C. W. Van Horn, *Citrus Growing in Arizona*, University of Arizona, Agricultural Experiment Station Bulletin 258 (Tucson, 1954), pp. 2-4.

[16] "First Action, New Area, Looks Good," *California Farmer*, 202 (April 2, 1955), p. 378.

CATTLE BREEDS, AN ASPECT OF REGIONAL GEOGRAPHY

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It is significant that, with few exceptions, cattle breeds have geographical names. Jersey, Guernsey, Ayrshire, Holstein-Frisian, Hereford, Aberdeen Angus, and Simmentaler are characteristic names of European cattle breeds, and each is reminiscent of a specific region or locality. Shorthorn is the notable exception, but Shorthorn cattle formerly were called Durham, and before that they were known as Teeswater cattle for the valley in which the breed was developed. The above names are established and well known, but there are dozens of others in Europe each distinctive and "native" to some particular region. Garner listed 26 distinctive British breeds. Moll described 40 in France alone, and the United States Consular reports for 1885 and 1886 list and differentiate large numbers of breeds for other European countries.

Since the story of the breeds is extremely broad and complex, this paper will be limited to background for two parts of that story: first, the early species and varieties from which cattle were domesticated and, second, the efforts to improve cattle under programs of scientific breeding which were largely the results of the work of Bakewell, Bates, Cruikshank, and Mendel.

Early Species

The first cattle may be divided into two groups, *Bos taurus* or European cattle and *Bos indicus*, the "Brahman" or Indian cattle. The distinguishing feature of the latter group, of course, is the hump. *Bos indicus* is important in Latin America and in the South along the Gulf Coast where its main use is for crossing with European cattle. Both purebred and crossbred Brahman cattle have a high degree of heat resistance, and the crosses show much hybrid vigor.

None of the species of Pleistocene cattle is living today, although our modern breeds are descended from them. Zoologists, archaeologists, and others have described many breeds or species of Pleistocene cattle such as *Bos trochoceros, B. frontosus, B. brachyceros, B. brochycephalus, B. typicus, B. longifrons*, and *B. primigenious*, but Morse stated that they should all be considered as forms of *B. primigenious*. It seems proper to maintain a differentiation between *B. primigenious* and *B. longifrons*, although those two became mixed—as probably did all other varieties mentioned. Furthermore, they may have mixed with *B. indicus* and a variety known to zoologists as *B. namadicus* which also appears to have been related to *B. indicus*.

Most distinctive among the extinct breeds was easily *Bos primigenious*, also known as *Urus, Ur, aurochs*, and the wild ox. It was a large, stately animal about six feet tall with long horns and with a long head, one skull having measured a yard in length. It roamed western Asia, North Africa,

and Europe, lived both in woods and steppe lands, and was contemporaneous with *Bos priscus* which was the ancestor of the modern European bison. It was mentioned by Caesar who saw the animal; it was drawn by artists who had seen it; and the last one died in a Polish museum in 1627. Stone Age drawings in caves in southwest France and northern Spain show wild cattle that are said to be of the two types, *Bos primigenious* and *Bos longifrons*. Drawings of the old Egyptians show cattle of the *primigenious* type as do drawings on early Greek vases.

Modern breeds that fit the type best are the white long-horned Hungarian cattle and the white Italian longhorns. In northwest Europe the Holstein-Frisian, Scottish Highland longhorns, and the wild White cattle of English parks are said to fit the type. Skeletons of *Bos primigenious* were found in Anau excavations.

Bos longifrons, also known in the literature as the Celtic Shorthorn, is a short-backed animal with short horns. It was usually but not always black in color. This was the "marsh cow," remains of which were found in Swiss Lake dwellings, and it was the common type of "native cattle" in the British Isles during the Roman invasion. As the succession of invasions took place, these cattle were displaced in the eastern and southern parts of England but were left in the west and north.

Bos longifrons is supposed to be best represented today by the Jersey which is the only breed found on the Isle of Jersey. Dexter and Kerry cattle also represent the old Celtic shorthorn type. Other breeds of western Europe carry the blood of *Bos longifrons*, and among them is the Spanish shorthorn, often found in the mountainous sections. Contrary to common belief, the Spanish fighting bull belongs in the shorthorn rather than the longhorn group. Certain other Spanish and Portuguese cattle properly belong in the longhorned or *Bos primigenious* group.

A great amount of mixing of breeds has gone on during the past thousand or two thousand years. Also, as people migrated they took their herds with them, subsisting on cattle as they moved. Even the Scandinavian ships of old carried cattle to the British Isles, to Iceland, and even to Greenland. That the land migrants of comparable times took many cattle with them cannot be doubted. Illustrating the complexity of the breeds and the possibility of their perpetuation, several authorities maintain that they can pick out the various ancient types today in the Smithfield pens in England. There are breeds which resemble the aurochs and others that fit the description of the Celtic shorthorn. Further complicating the picture in the British Isles was the introduction of polled or hornless Scandinavian cattle. Polled cattle are to be found along the east coast of Scotland in the Aberdeen Angus and even down to the Suffolk cattle of the south of England. It is relatively simple to "breed the horns off a breed of cattle."

Criteria for Classification

In classifying cattle, various characteristics have been used. Color, size, and conformation are significant; so is the nature of the hair, whether it is short, long, or long and curly. The horns are significant in designating breeds, some having especially long horns and others short horns, while still others are hornless. The shape of the horns is often noted and archaeologists have paid considerable attention to bone structure.

On the utilitarian side, size and rate of growth, breadth and stature, quality of beef, milk quantity and its butterfat content, value as a draft animal, tractability, longevity, and such features help classify cattle into breeds. Another prominent characteristic is ability to survive, whether it be heat of summer, cold of winter, or the long winter period of starvation conditions. Growth and fattening qualities and ability to survive usually go in opposites. It is significant that none of the best commercial beef breeds of the British Isles were developed in the northern or western hill sections, even though the breeds of those regions are extremely hardy and inured to the harshest of winters. Shaggy Highland cattle can live on next to nothing and "carry roofs on their backs," but they are not superior beef animals.

Under the old European system of husbandry, besides furnishing manure and hides, the cattle not only provided beef and milk but also served as draft animals. In Italy draft may even have been most important, while in the Netherlands milk production was most highly valued.

The big white Charolaise cattle of France were both beef and dairy cattle but they also served as draft animals. The same can be said for the yellowish white-faced Simmentalers of Switzerland and Germany. In Italy and Hungary the big white longhorned breeds were primarily regarded as work stock but were also dairy and beef cattle. Brown Swiss and Pinzgauer cattle in Switzerland and Austria were mere dual purpose cattle. In the Netherlands where dairying took precedence over everything else, the big black and white Holstein-Frisians long ago came into prominence. Local longhorned cattle in eastern England served all purposes at a time when every cow might be a dairy cow and every dairy cow was a potential beef animal. In Europe there was little specialization, and the folkways and rural economies demanded cattle for draft, meat, milk, and hides as well as manure which was essential to the farming system.

Scientific Breeding in the British Isles

Robert Bakewell, who lived in Leicestershire and began breeding stock in 1745, is given credit for revolutionizing the science of animal genetics. In addition to increased demands for beef, improved feeds in the form of planted grasses and later the Swedish turnip, greatly accelerated his work. He believed that "likes beget likes," and he "bred the best to the best" even when it called for close inbreeding. The keys to his success were inbreeding, close selection with the use of proven sires, and out-crossing. His pupils carried on his work in different areas and with different strains of cattle. Collings worked with Shorthorns in general, Bates developed Shorthorns as a dual-purpose breed, and Cruikshank developed the Scotch Beef Shorthorns and played an important role in exporting them to other parts of the world. Many other breeders followed these methods and developed additional British types. Pedigrees and closed herdbooks played a significant part in the commercial development as did advertising and the publicity given the improved cattle, which did so well under improved feeding conditions. Out of Britain came the three prominent beef breeds: Hereford, Shorthorn, and Aberdeen Angus. The continent contributed the large Holstein-Frisian dairy breed, and meanwhile from the Channel Islands came Jerseys and Guernseys, which for a time were called Alderneys.

Jersey cattle were of the *Bos Longifrons* type and were small and scrawny

on their home islands but in the eighteenth century these so-called Alderneys were exported to England where, with improved care, they became better producers and were said to be of "very fancy colour and fit for a gentleman's park." Jersey cows were carried on sailing ships for milk and cream and were frequently sold to New England farmers. Although popular in some places, they were ridiculed in others. Upon seeing one at a fair, a midwestern farmer commented "A Jersey might be all right for a man who is too poor to keep a cow but too proud to keep a goat." However, because of her docility, small size, and rich milk, the Jersey became the favorite family cow and pet, as well as the most widespread of all dairy breeds in America. Introduced at a later period, the much larger Holstein-Frisian is short-lived as a milk producer but has a tremendous carcass when slaughtered after three or four productive years in the modern drylot dairy. For milking purposes, the Holstein has generally displaced the Jersey, but the greater heat tolerance of the latter favors its continued use throughout the South.

The Holstein conquest is now almost complete in Southern California, and Holstein expansion is going on in the dairies of Latin America, the British Isles, and the continent of Europe. Feeding, housing, care, and almost all of the conditions affecting the dairy cow are today man-made or man-controlled, especially in the drylot dairies. The heat problem remains unsolved but even that is somewhat ameliorated. Although there are many other good dairy breeds, the modern cow must be a specialist, and as a producer of market milk the Holstein-Frisian is second to none.

Beef Cattle in America

The beef cattle brought originally to eastern seaboard America were native breeds of western Europe, just as the cattle introduced into Latin America were ordinary Iberian stock of that period. These hardy cattle spread from the West Indian Islands to Mexico, and from there to Texas and California. They were "big of bone and fleet of foot," able to walk long distances to waterholes, and strong enough to protect their calves against wolves. Well publicized as the so-called Texas longhorns of the open range, they were well suited to the time and the place. Following the War Between the States, the outbound Texas cattle drives distributed longhorns the length of the Great Plains to Canada. It was soon apparent that the ability to survive the rigors of the range was not enough. The big horned cattle took too long to mature; they did not fatten well in a feed lot and when driven to the slaughter house at three or four years of age, made poor beef in competition with English beef cattle types marketed direct from the Corn Belt farms.

During the first half of the past century, the more compact breeds from the British Isles had been gradually introduced into eastern and midwestern farms. In time the raising of blooded cattle had become not only a business but a fad. Britain provided the original stock, but American cattlemen imported them, registered them in American herdbooks, and soon popularized them throughout the country. On the western plains the ranches which succeeded the open range bought high priced sires with which to upgrade their old stock. The upturn in the quality of beef animals, with younger cattle going to the feedlot, meant better beef from the slaughter house and on the family table, all part of a general improvement which led to competition between breeds and breeders, as well as fabulous prices frequently

paid for choice pedigreed animals exhibited at the national livestock shows. During one period Aberdeen-Angus were also popular, but the whitefaced Hereford was the breed most widely adopted. It thrives under good conditions and bad, endures both heat and cold, and its geographical range extends from Mexico into Canada. It stands in somewhat the same relationship to other beef cattle as the Holstein-Frisian does to other dairy breeds.

In the humid South, Brahman cattle and Brahman crosses are highly regarded. In habitats where survival is the prime consideration, scrubby crosses still have their place. Newly fixed breeds such as the Santa Gertrudis, Brangus, and Beefmaster are having a limited acceptance in competition with the longer established types. Hopeful breeders are constantly engaged in fixing and testing various strains, hoping to find an even better one. As a whole, however, the cattle business of America tends to rely on the three accepted types: Hereford, Shorthorn, and Aberdeen-Angus.

A Specialized Regionalism?

In conclusion, the question might well be raised: does the United States have too many or too few breeds of cattle? America is large and its regional conditions are highly diverse. Cattle are raised, pastured, milked, fattened for market under highly varied conditions of relief, climate, altitude, soil, and pasturage. It is doubtful that any all-purpose breed has been or can be developed to satisfy such regional diversity. No one animal can be an equally efficient producer in the hottest desert, the coldest plateau, the muggiest lowlands, and the richest grasslands. Plant breeders search the world to find characteristics which will make, under modern genetics, the most efficient contribution for any given condition. Similarly, a more specialized regionalism in the cattle business, with more breeds tailored to suit their optimum environments, may be the ultimate answer.

GENERAL BIBLIOGRAPHY AND NOTES

In 1954 the writer made a tour of eight European countries during which he studied 15 distinct breeds of cattle. Eight of these are well known in this country, three others were recognizable through previously having seen pictures of them, and four were completely unknown at the time of observation. In the order in which they were first seen, the 15 breeds were Norman or Cotentin, Charolaise, Limousin, White Italian, Pinzgauer, Brown Swiss, Simmental, Holstein-Frisian, Ysel, Groningen, Jersey, Hereford, Aberdeen Angus, Ayrshire, and Milking Shorthorn. The investigation included the purposes for which these cattle were kept as well as the different methods of grassland farming.

Appended are some of the more valuable references used in the preparation of this paper, with brief comments.

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THE MONTEREY PINE (PINUS RADIATA) IN NEW ZEALAND

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In New Zealand the introduction of exotic plants and animals in an attempt to improve the biotic environment has been a continuing process dating back to the Maori in the pre-European era. However, in an isolated and insular environment such as this, there is an ever-attendant risk that the intricate balances of nature may be upset. The rabbit scourge, highly publicized in Australia but also serious in New Zealand, is frequently cited as the classic example of the near disastrous results of introducing a foreign specie into a region where none of its natural enemies exist. Other examples include the European red deer, the Wapiti (Roosevelt elk), the English sparrow, and the starling, all of which have become unwelcome pests, while Scotch gorse has run rampant over large areas. This list of failures is not long by comparison with the many successes which have gradually transformed the biotic landscape of New Zealand into a southern hemisphere approximation of northwest Europe.

Among the more recent of the successful exotics has been the Monterey pine *(pinus radiata)*,[1] indigenous to the coast of central California. Although systematic propagation of this tree was not begun until after World War I, its growth has been so rapid that entire forests are now reaching maturity and their exploitation has brought into existence, within the last four years, the largest softwood timber industry in the southern hemisphere. Wood products now rank fourth in export value in New Zealand, exceeded only by the long established wool, meat, and dairy products industries.[2]

The tree derives its name from its limited occurrence on the Monterey peninsula and adjacent areas of California. In its natural habitat, the Monterey pine has never been seriously considered as having even a remote timber potential, for not only is its range as restricted as any tree in the United States, but it is typically stunted, knotty, and somewhat slow growing as a result of low precipitation, cool temperatures, high winds, thin soils, and heavy fog. There are no really large stands of *pinus radiata* even on the peninsula; the groves are widely scattered and are found only as far north as Ano Nuevo point and south to San Simeon on the mainland. Actually, this pine is a relict of the pre-ice period, probably originating in the late Tertiary as an insular endemic when the California coast ranges were a series of disconnected islands paralleling a more easterly coastline. Isolated trees may still be encountered on islands off the coast of southern California and northern Mexico.

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[1] *Pinus insignis* is an older designation for the identical specie.

[2] New Zealand, Department of Statistics, *New Zealand Official Yearbook, 1958*. Wellington, 1958, p. 489.

The major pine forests in New Zealand are located on a broad rolling upland in the north central part of the North Island. Fringed by mountains on all sides except the north, this triangular shaped plateau, its apex at Lake Taupo, its base fronting on the Bay of Plenty, has a total area of almost 3000 square miles. Successive lava flows combined with magmatic intrusions have raised it to its present 500- to 1000-foot elevation, and it is characterized by frequent seismic activity and the widespread occurrence of geysers and steam vents. Locally, the entire region is known as the Pumiceland (Fig. 1). Contrary to common American usage, the term pumice in New Zealand is applied indiscriminately to any and all volcanic ash, and the Pumiceland is mantled throughout with varying thicknesses of ash derived from recently active volcanoes along its southern and southwestern margins. As a result, the original climax vegetation was obliterated. When first viewed by Europeans, the region, despite thirty or more inches of well-distributed rainfall each year, a fifty-five to sixty degree temperature average and, by New Zealand standards, a higher than average incidence of sunshine, had a semi-desert appearance with only a widely spaced tussock grass and stunted scrub cover. The forest oriented Maori had shunned this barren upland, but to Europeans the open country appeared to offer emancipation from laborious and costly clearing of forest land and to have a potential for extensive grazing. This was attempted for a few years but it soon became apparent that there was something wrong with the ash soil; both the native tussock and newly seeded pastures were found to be lacking in nourishment. Their herds declining from what was termed "bush sickness," European settlers soon abandoned the Pumiceland as unfit for human occupance.

Afforestation in the Pumiceland

Afforestation on a small scale was begun in New Zealand as early as 1900 by both private individuals and government agencies in an effort to check watershed deterioration and erosion. In the rush for agricultural and grazing property following the Maori wars, large areas of marginal and slope land were cleared of original forest, later abandoned and burned over. Furthermore, it was becoming increasingly obvious that the slow growing Kauri and Rimu, the chief indigenous timber trees in the Islands, were being cut at a much more rapid rate than they could replace themselves, and New Zealand was approaching a serious timber shortage. With this contingency in mind, Pumiceland boosters in the North Island began some experiments to determine whether the hitherto barren ash might be capable of supporting deep rooted conifers (Fig. 2).[3]

As organized afforestation became more widespread, eventually reaching a peak in the late 20s and early 30s, the selection of the species best suited to the local conditions received prime consideration. It soon became apparent that exotic conifers were, in nearly all cases, far superior to any of the native varieties. The first to be planted on a large scale were the proven timber trees from similar climatic regions in North America and Europe:

[3] New Zealand, Forest Service, *Forestry in New Zealand*, New Zealand Forest Service Information Series No. 1. Wellington, 1957, pp. 2-6.

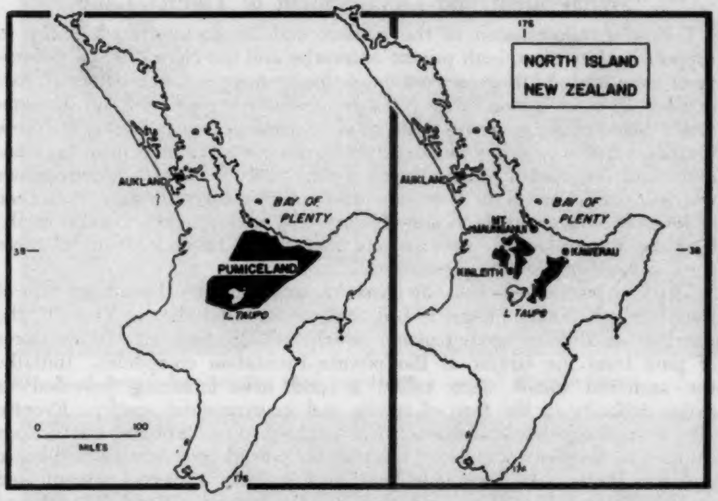

Fig. 1. (left) Volcanic ash mantles an important segment of the North Island. Fig. 2. (right) Approximately one half of the Pumiceland is in forest today (black area).

Douglas fir, redwood, Ponderosa pine, and Corsican pine. Each was moderately successful in certain limited situations, but no one demonstrated the versatility required for a general purpose tree. Almost as an afterthought the Monterey pine was tried and, surprising even the experts, proved to be the most adaptable of all the exotics. It grew well throughout nearly all of New Zealand under a variety of climatic and soil conditions (including most pumice soils), matured to a merchantable timber tree in twenty to thirty years (double the rate of growth in its native California habitat), and produced a satisfactory grade of lumber in addition to being suitable for pulp, paper, hardboard, and a wide range of secondary products.[4] By the time the Pumiceland was afforested, the Monterey pine had proved its worth as a source of wood products and was, henceforth, planted almost exclusively over an extensive region that had never known trees in historic time.

Despite some original poor planting stock, improper spacing, occasional fires, and inadequate forest management the trees grew well, and today entire forests of twenty- to thirty-year-old radiata are ready for cutting. New Zealand is not only self-sufficient in softwood timber products after years of shortages but is an increasingly prominent exporter—the entire operation based on the quick-growing pine forests of the previously unproductive Pumiceland.

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[4] New Zealand, Forest Service, *The Silviculture of Exotic Conifers in New Zealand*, Report of British Commonwealth Forestry Conference. Wellington, 1952, pp. 8-10.

Management and Development of Timber Land

Following afforestation of the plateau and its demonstrated ability to support healthy trees, both private enterprise and the New Zealand government were tardy in their recognition of this growing resource potential, particularly in making long range plans for scientific exploitation and development. Some of the area was designated as national forest reserve, and here the understaffed and underfinanced forest service attempted pruning, thinning, and fire control on a limited scale. Elsewhere, private companies which had sold bonds all over the world entitling the purchaser to an acre of forested land, maintained some token forest management. On the whole, however, there was no agreement on what should be done to utilize these trees as a self-perpetuating resource.[5]

The first positive move in this direction was made by the private firm of New Zealand Forest Products, Ltd. (better known today as Kinleith, the name of its large integrated plant) which in 1935 acquired 176,000 acres of pine from the largest of the private forestation companies. Initially, the scattered bonds were called in and new financing provided—a major difficulty in the face of public and governmental apathy. Eventually, a small experimental sawmill was established in 1939 and sample logs shipped to Sweden for pulping tests which proved successful; a wallboard mill was built at Penrose, Auckland, and in 1948 a second sawmill and multiwall paper bag plant were put into production. World War II and difficulty in obtaining private financing in New Zealand at first limited company development, but following the war a campaign to enlist capital was initiated in Australia, chronically short of domestic softwoods. Several Australian paper concerns, interested in the potential source of pulp and paper, together with some life assurance companies invested heavily, and today over 50 per cent of Kinleith's shareholders are Australian. This fresh infusion of capital financed the construction of a £7,000,000 integrated plant in the heart of the company forest holdings some one hundred forty miles south of Auckland. The large Kinleith sawmill, kraft paper and pulp mill, timber treatment plant, veneer plant, shook factory, and kiln drying unit are all connected by rail with outlying plants and with the harbors at Auckland and on the Bay of Plenty. Four and one-half miles away at Tokaroa (original population 140) the company has built a model town to house its workers and their families who now number in excess of 6000 persons.[6]

A second large scale wood products development based on Pumiceland pine began operation recently. It is government sponsored and utilizes the timber from the 284,000 acre Kaingaroa State Forest near Rotorua. A pilot sawmill was established and in 1949, after tests proved that resin and other problems associated with making newsprint from Monterey pine could be overcome under volume operation, foreign consultants reported favorably on the feasibility of an integrated sawmill and pulp and paper operation. In 1951 the government issued an open invitation for bids on such a plant. The offer of the Tasman Group, composed of British and New Zealand financial interests and a number of foreign technicians, was accepted and the Tasman Pulp and Paper Company, Ltd. was formed. Although two of

[5] *Wellington Evening Post, Forestry Supplement,* June 14, 1957, p. 3.

[6] *Our Pine Industries.* Penrose, Auckland: New Zealand Forest Products, Ltd., 1956, p. 18.

Fig. 3. A heavy duty logging road penetrates a mature Kinleith forest.

Fig. 4. Felling trees is a quick job with a power saw. The average time is one tree per minute or roughly one acre of forest per day.

its directors were appointed by the Crown, it was essentially a private venture, the government participating only as a forest owner and aiding in the development of rail, harbor, and power facilities. The company contract permits cutting up to 23,000 cubic feet of logs annually for twenty-five years with a renewal option for subsequent periods.[7]

The immediate agenda of the new company called for the construction of a pulp mill, newsprint mill, and a sawmill at Kawerau thirty miles north of the forest proper, and the building of a modern deepwater port at Mt. Maunganui on the Bay of Plenty, some forty miles northwest of Kawerau. These were linked with each other and the forest by rail and heavy-duty logging roads. In addition, new towns were laid out at Kawerau to accom-

[7] "Tasman, The Largest Sawmill in the Southern Hemisphere," *Australian Timber Journal.* Oct. 1956, p. 4.

modate millworkers, and at Marupara at the forest railhead, to house the logging gangs. Completed in 1956, the entire plant is now operating at near capacity and carrying on an expansion program in its newsprint operation.[8]

In the development of New Zealand's forest products industry, foreign capital, consultants, equipment, and established techniques have been used freely. The sawmills employ almost exclusively American band saws and Swedish gang saws. The revolutionary continuous digesters of which Kinleith has six, the largest group in operation in the world, are of Swedish design and manufacture. The logging equipment, including tractors, cranes, heavy hauling trucks, and railway cars, is also of foreign origin.[9] In addition many of the key personnel involved in both the original planning and construction and in the day-to-day operation are from overseas.[10]

Both the Kinleith and Tasman companies are completely integrated operations utilizing previously wasted sawmill and logging by-products—chips, sawdust, bark, slash, and small trees—as raw materials for paper, pulp, and insulating board. Both have research laboratories which handle problems such as the commercial extraction of turpentine and resins, and contribute to increasingly efficient wood processing. At Kawerau they are attempting to adapt the spectacular geothermal energy of natural underground steam, tapped by deep bores in many parts of the Pumiceland, to the production of electric power and the drying of lumber in steam-heated kilns.[11] New Zealand forestry experts claim that their wood conversion plants are now the most modern in the world.[12]

Similarly, the logging methods as practiced in the woods are an amalgam of the best and most efficient techniques of Scandinavia, Canada, and the United States. The clean cut block system, pioneered in the Pacific Northwest in recent years, is applied. A block is logged clean, each tree being cut flush with the ground, and the timber channeled to the sawmill, veneer plant, or pulp mill as size and quality dictate. Normally, the adjacent block of mature trees reseeds the logged off block within one year, the Monterey pine being a prolific seed producer. On the relatively flat terrain of the Pumiceland, the cost of log removal by truck and caterpillar tractor is modest, and the use of chain saws speeds the entire operation. The long range plan calls for a thirty to forty year cycle for mature timber trees and somewhat less for blocks intended for pulp. In the meantime, scientific pruning and thinning is directed toward the production of an optimum end product.[13]

Kinleith and Tasman together produce the bulk of all wood products in New Zealand, close to 90 per cent of the total. Kinleith's operation is the more diversified producing sawed timber, kraft paper and pulp, insulating board, hardboard, multiwalled paper bags, solid board containers, wooden cases, shook, veneer, and plywood. Tasman is the exclusive New Zealand

[8] *Op. cit., Forestry in New Zealand*, p. 17.

[9] *Op. cit., Wellington Evening Post, Forestry Supplement*, p. 7.

[10] The Southland Paper Mills of Lufkin, Texas, assisted in setting up the production of high grade newsprint from Monterey pine, using paper-making techniques adapted from their Southern yellow pine operation.

[11] *Tasman Pulp and Paper*. Washington: New Zealand Embassy, Oct. 1958, p. 9.

[12] *Tasman*. Auckland: Tasman Pulp and Paper Co., Ltd., 1954, p. 6.

[13] *Silviculture of Exotic Conifers in New Zealand, Op. cit.*, p. 10.

source of newsprint, but in addition produces only sawed timber and kraft pulp. The latest published figures show the major categories.

MAJOR CATEGORIES OF WOOD PRODUCTS—1958[14]

	Kinleith	*Tasman*
Sawed timber	75,000,000 bd. ft.	40,500,000 bd. ft.
Kraft pulp	65,000 tons	39,000 tons
Kraft paper	30,000 tons	———
Newsprint	———	75,000 tons

An increasing amount of the total is destined for export, and with the relatively small local market satisfied, foreign demand may set the limits of the future New Zealand wood products industry. Due to its domestic softwood shortages, propinquity, and Commonwealth membership, Australia has to date taken the largest amount of exports but other Commonwealth nations including Britain are future prospects, many having already accepted small shipments on a trial basis. Some potential customers are not yet aware that wood products are being offered, and others are understandably wary of a product made from the little known radiata. Company sales representatives realize this and are presently engaged in an aggressive world selling program. The future of wood exports appears reasonably secure, for within the Commonwealth only Canada is an active competitor.

EXPORTS OF NEW ZEALAND WOOD PRODUCTS—1958[15]

Sawed timber	30,000,000 bd. ft.
Wood pulp	64,994 tons
Newsprint	35,902 tons

Any major increase of the area now under silviculture in New Zealand is improbable and stabilization at or near the present level of production seems to be the trend. The longstanding disagreement between those who would plant the Pumiceland to trees and those who would reserve its use for grazing and agriculture appeared to be permanently resolved when approximately half of the area was successfully afforested. However, it has been demonstrated recently that with the addition of minute quantities of cobalt the pumice soils can produce excellent pasture; consequently the unforested areas are now in demand as first class grazing and dairy land.[16] Thus it appears today that the old argument has reached a mutually agreeable stalemate and no one suggests that either type of land use encroach upon the other. Actually, the forests can be made even more productive within their present limits for much of the original planting and subsequent management was faulty, and these errors can be rectified following the initial cut. A very high percentage of the total area was planted within one ten-year period leading to the maturation of the entire forest at about the same time. The ratio of Monterey pine to other species is questioned by some forestry men; it is so high as to possibly encourage disease and insect attacks on an epidemic scale. However, despite these problems, the Monterey pine

[14] *New Zealand Official Yearbook, Op. cit., 1959,* p. 557.

[15] *Ibid.,* p. 562.

[16] P. W. Smallfield, "Pumiceland Development in Central North Island," *New Zealand Journal of Agriculture.* May 15, 1954, p. 421.

is the firm base of the New Zealand forest economy. The wood product companies, the forest service, and various government and university scientists are concentrating their experiments on it, including improved management, fire control, better seeds, and fertilization, all aimed at realizing maximum long range yields of optimum quality.

TWENTY-SECOND ANNUAL MEETING

San Diego State College

June 16-18, 1959

The twenty-second annual meeting of the Association was held at San Diego State College, San Diego, California, with Dr. James W. Taylor as chairman of local arrangements. Four half-day sessions were devoted to research papers and a business meeting. The address of retiring President Francis J. Schadegg was presented Wednesday evening, June 17, at the annual dinner.

Program

BOYCE, RONALD R., *Western Washington College, Bellingham*
"The Central Business District Core-Frame Concept and Some of Its Implications."

COLE, CHESTER F., *Fresno State College*
"Coalinga's Water Supply."

EDWARDS, CLINTON R., *University of California, Berkeley*
"Peruvian Sailing Rafts: Problems of Their Origin."

*GREGOR, HOWARD F., *San Jose State College*
"Fact and Fancy in the Desert Farming of Southeastern California."

JOHNSON, MARTIN E., *University of California, Los Angeles*
"Contrasts in the Indigenous Economies of Three African Peoples of the South Sudan."

KIRBY, PATRICK, *University of California, Los Angeles*
"The Changing Character of Nakuru, Kenya."

KRAMER, FRITZ L., *University of Nevada*
"Some Features in the Vicinity of Wheeler Peak, Nevada."

*McINTYRE, MICHAEL P., *San Jose State College*
"The Monterey Pine Makes Good in New Zealand."

PECK, ELMER W., *Riverside City College*
"Air Pollution in the San Bernardino Valley."

*POST, LAUREN C., *San Diego State College*
"Cattle Breeds as a Feature of Regional Geography."

*RUDD, R. D., *Oregon State College*
"An Alternate Interpretation of Koeppen's Dsb Climate in Oregon."

SPENCER, JOSEPH E., *University of California, Los Angeles*
"Some Historical Considerations of Trade and Production in Southeast Asia."

VANCE, JAMES E., JR., *University of California, Berkeley*
"Urban Areal-Political Structure."

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[illegible], University of California, Berkeley
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*[illegible], Robert F., San Jose State College
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[illegible], University of California, Los Angeles
"[illegible] in the [illegible] of Three African Peoples of the South [illegible]."

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